Ecological Restoration of Degraded Ecosystems in Tamil Nadu: Planning and Implementation

Workshop Programme and Abstracts

Organisers

Tamil Nadu Forest Department
Nature Conservation Foundation, Mysore
UNDP-Post-tsunami Environment Initiative

December 2006, Chennai

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ECOLOGICAL RESTORATION OF DEGRADED ECOSYSTEMS IN TAMIL NADU: PLANNING AND IMPLEMENTATION

WORKSHOP PROGRAMME

Venue: Conference Hall (1st Floor), Panagal Building, 1 Jeenis Road, Saidapet, Chennai 600015
Date: 19 December 2006, Tuesday
Organized by: Tamil Nadu Forest Department, Nature Conservation Foundation, Mysore, and UNDP-Post-tsunami Environment Initiative

INAUGURAL SESSION
(9.30 – 10.35 hrs)

9.30 AM	Invocation	
9.35–9.45	Welcome address	Dr. S. Balaji, I.F.S. Chief Conservator of Forests (HQ)
9.45–10.00	Keynote address	Dr. C. K. Sreedharan, I.F.S. Principal Chief Conservator of Forests
10.00–10.15	Inaugural address	Mr. Viswanath Shegaonkar, I.A.S. Secretary, Environment & Forests Department, Government of Tamil Nadu
10.15–10.35	The role for ecological restoration in conservation of biological diversity	Dr. T. R. Shankar Raman, Nature Conservation Foundation, Mysore

TEA : 10.35 – 10.50 hrs

TECHNICAL SESSION – I
(10.50 – 13.30 hrs)

Time (hrs)	Topic	Speakers
10.50–11.10	Forest biodiversity restoration through Tamil Nadu Afforestation Programme	Mr. K. P. M. Perrumahl, I.F.S. Chief Conservator of Forests (TAP)
11.10–11.30	Reviving traditional agricultural ecosystems: building on traditional knowledge and wisdom	Mr. A. V. Balasubramanian, Centre for Indian Knowledge Systems, Chennai
11.30–11.50	Status of coastal and marine ecosystems and species diversity of India and future perspectives	Dr. V. K. Melkani, I.F.S., Chief Conservator of Forests, GOMBRT, Nagapattinam

11.50–12.10	Conservation and stabilization of dunes: experiences from South Poigainallur, Tamil Nadu	Mr. R. Balakrishnan, Panchayat President, South Poigainallur
12.10–12.30	Conservation of sandy beaches and dunes	Dr. Kartik Shanker, Centre for Ecological Sciences & ATREE, Bangalore
12.30–12.50	Science-based community-centred approach to restore degraded mangrove wetlands	Dr. V. Selvam, M. S. Swaminathan Research Foundation, Chennai
12.50–13.10	Restoration of coastal ecosystems – need and strategies	Dr. J. K. Patterson Edwards, Suganthi Devadason Marine Research Institute, Tuticorin
13.10–13.30	Overview: conservation and restoration for management of marine and coastal areas	Dr. Rohan Arthur, Nature Conservation Foundation, Mysore

LUNCH : 13.30 – 14.10 hrs

TECHNICAL SESSION – 2
(14.10 – 15.50 hrs)

Time (hrs)	Topic	Speakers
14.10–14.30	The restoration of tropical dry evergreen forests ecologically and socially	Mr. Paul Blanchflower, Auroville Botanical Gardens, Pondicherry
14.30 –14.50	When and where do we need restoration? An assessment from the deciduous forests	Dr. M.D. Madhusudan, Nature Conservation Foundation, Mysore
14.50 – 15.10	Ecological restoration in a fragmented rainforest landscape in the Anamalai hills	Dr. Divya Mudappa, Nature Conservation Foundation, Mysore
15.10 – 15.30	Changing priorities in the management of the shola-grasslands landscape	Mr. Robert Stewart & Ms. Tanya Balcar, Vattakanal Conservation Trust, Kodaikanal
15.30 – 15.50	The role of ex-situ conservation in restoration practice: lessons from 25 years of plant conservation at the Gurukula Botanical Sanctuary, Wayanad, Kerala	Ms. Suprabha Seshan, Gurukula Botanical Sanctuary, Wayanad

TEA: 15.50 – 16.10 hrs

TECHNICAL SESSION – 3
(16.10 – 17.25 hrs)

16.00 – 17.25	**Panel discussion** Best practices / guidelines for management of various ecosystems in Tamil Nadu	**Chairman**: Dr. C. K. Sreedharan, I.F.S. **Panelists**: 1) Dr. S. Balaji, I.F.S. 2) Dr. V. K. Melkani, I.F.S. 3) Dr. K. Krishna Kumar, I. F. S. 4) Dr. Ravi Chellam 5) Dr. Rauf Ali 6) Dr. M. D. Madhusudan 7) Dr. R. J. Ranjit Daniels 8) Dr. N. Parthasarathy
17.25	Vote of thanks	Dr. Rohan Arthur Nature Conservation Foundation, Mysore

17.30 National Anthem

The role for ecological restoration in conservation of biological diversity

T. R. SHANKAR RAMAN & DIVYA MUDAPPA

Nature Conservation Foundation, 3076/5, IV Cross, Gokulam Park, Mysore 570 002
Rainforest Restoration Research Station, 8/364 Cooperative Colony, Valparai 642 127, Tamil Nadu (Tel: +91 4253 221527; Email: podocarp@vsnl.net)

Ecologists of the present century have to contend with most previously pristine landscapes now containing only remnant fragments of natural ecosystems, amidst degraded areas and human-impacted sites. This has contributed to the present global extinction crisis, unprecedented in scale and impact since the time of the extinction of the dinosaurs and other life nearly 65 million years ago. Around the world, the survival of a large part of the remaining diversity of living organisms now hinges crucially upon their ability to persist in human-modified landscapes and on our efforts to conserve them. Conservationists around the world increasingly realise the need to supplement conventional efforts such as creation of protected areas by active efforts to conserve habitats adjoining protected areas, increase landscape-level connectivity of remnants, and to ecologically restore degraded areas.

Ecological restoration of degraded habitats is now regarded as an effective response to reduce and reverse the negative effects of habitat loss, degradation, and fragmentation on native biological diversity and ecological processes. *Ecological restoration is defined as the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.* Recovery is normally taken to imply the revival of the indigenous species assemblages, biophysical structure, and ecological functions characteristic of the desired target state. The target state for restoration is usually taken to be the state of the ecosystem as it was prior to human disturbance. In the absence of information on the prior state, the target is taken to be the state of the ecosystem as currently represented in comparable benchmark areas or reference sites. Benchmark areas are those that have been subjected to little or no human impact and are located in the same region and vegetation type under similar environmental conditions of rainfall, topography, or elevation.

Restoration is complementary to other approaches at conservation such as *protection* of biologically important areas. It may be avoided in relatively large and continuous tracts of natural habitat that continue to retain native species in the landscape. Such areas usually have a high potential for recovery through natural processes and regeneration under protection, particularly in the absence of major external human-induced disturbances. Other approaches such as

reclamation and rehabilitation may also be required for certain types of sites in the landscape, although native biological diversity may or may not benefit. *Reclamation* (similar to some afforestation programmes) principally uses exotic species to overcome degradation in highly degraded areas such as mine spoils and sites where the top soil has been lost, because exotics may provide better economic returns or may manage to establish rapidly. In *rehabilitation* programmes, aimed merely to ameliorate site conditions and not intending to bring back original conditions, native and exotic (non-indigenous) species considered ecologically or economically necessary may be used.

In degraded sites where intervention is considered necessary and conservation of biological diversity is the main consideration, ecological restoration focussing on a mixed diversity of native species is the method of choice. Another feature of most restoration projects is the active removal of exotic, particularly invasive, weed species. To be effective, restoration projects need to be based on a clear understanding of both the natural and ecological history of the targeted sites, and pay due attention to ethical, aesthetic, economic, and cultural considerations.

Examples of successful restoration projects are growing in a diversity of ecological settings around the world. These range from bringing back tropical forests on bauxite-mined lands and secondary forests, restoring forest corridors to connect fragments, restoring inland water bodies, marshes and stream-side vegetation, restoration of coastal ecosystems and coral reefs, removal and re-contouring of hill roads through forests, decommissioning of dams and restoration of river systems, and restoration of prairie and montane grasslands. Such plant and habitat-centric restoration may serve as a foundation for restoration of animal communities, in cases where natural recolonisation of particular taxa does not occur. It may also involve restoration of habitat linkages to facilitate animal movement such as providing tree canopy connectivity across roads and clearings and by means of carefully designed and located faunal underpasses below roads and linear clearings that impede animal movement and dispersal.

The rapidly advancing field of ecological restoration poses significant challenges for ecological theory and conservation practice. It retains close conceptual and practical links with the fields of conservation biology, biological invasions, and ecosystem ecology. Perhaps, most important, it also gives itself nicely to community-based and participatory approaches and the involvement of a wide section of people in biodiversity conservation. There is a critical need to garner more experience in restoration of various ecosystems and to learn by doing. A key aspect essential for all restoration projects is proper photographic, qualitative, and quantitative documentation of restoration efforts and regular, systematic monitoring to assess restoration success towards the desired target state.

T. R. Shankar Raman is a scientist at the Nature Conservation Foundation, Mysore. He is involved in projects on rainforest restoration and bird communities in the Anamalai hills, Western Ghats. He holds a Master's degree in Wildlife Science from the Wildlife Institute of India and a doctorate from the Indian Institute of Science. He has carried out studies on deer in southern India and on birds and mammals in tropical rainforests of northeast and southwest India. His interests are in rainforest conservation, restoration, and monitoring.

Divya Mudappa is a scientist at the Nature Conservation Foundation, Mysore, currently engaged in mammal conservation and rainforest restoration projects in the Anamalai hills, Western Ghats. She holds a Master's degree in Ecology from Pondicherry University and a doctorate in Conservation Biology from Bharathiar University and the Wildlife Institute of India. She has studied hornbills, rainforest plants, small mammals and carnivores, and Asian elephants. Her interests are in the fields of plant-animal interactions, conservation biology, and restoration ecology in tropical rainforests.

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Forest biodiversity conservation through Tamilnadu afforestation project

K. P. M. PERRUMAHL, I. F. S.

Chief Conservator of Forests, Tamilnadu Afforestation Project, Panagal Building, 1 Jeenis Road, Saidapet 600 015, Tamil Nadu (Email: ccftap@tn.nic.in)

India is one of the 12 mega biodiversity countries in the world. With 2.4% of the global land area India has 7 to 8% of the species recorded so far in the world. Forests are the primary repository of all forms of biodiversity. Forests meet 40% of the national energy needs and 30% of the fodder needs of India. The state of Tamilnadu has 17.41% of its land area under forests and forests of both Western Ghats and Eastern Ghats are rich in biodiversity. However, 46.97% of these forests are degraded. There are about 3072 forest fringe villages and most of the people living in these villages depend totally or partially on forests for their livelihood. Poverty among these villagers has played a major role in degradation of forests and consequent loss of biodiversity. Earlier efforts in rehabilitation of these degraded forests through various schemes have not met with expected success since the people living nearby these forests were not participating in these efforts.

To halt and reverse this dangerous trend Tamilnadu launched a massive project captioned Tamilnadu Afforestation Project (Phase I) from 1997 to protect, conserve, and manage the biodiversity at local or micro level. The theme of the Project is people's participation, forest conservation, and poverty alleviation. The people who directly and indirectly impacted on these forests were made part and parcel of the conservation efforts. The Project employed Joint Forest Management as a major tool for local biodiversity conservation. The local communities were organized into a grass-root level institution called Village Forest Council (VFC). From 1997 to 2004, 1367 VFCs were formed and nearly 4.66 lakh local people became active members in the co-management of the forests. They conduct a Participatory Rural Appraisal (PRA) to identify, decide, and prioritize the needs and the project activities and draw a Micro Plan.

The Project devised in-situ biodiversity conservation in its degraded forests to enrich the bio-resources. Degraded forests with a crown density of less than 0.4 were restored. Over 50 native tree varieties, most of them of local economic value were planted. The degraded forests over an extent of 4800 sq. km was biologically restored and ecologically upgraded in the eight years of the Project. There has been an excellent and visible change in the status of these forests due to profuse regeneration. This Project also laid much focus on watershed development through in-situ soil and moisture conservation to

prevent topsoil erosion and to encourage secondary vegetation and soil stability. Besides these works, the Project embarked on a massive effort to make water available to the villagers by constructing 23454 check dams and 2201 percolation ponds in Phase I of the Project, which resulted in a rise in the water table to an extent of 5 to 10 percent giving fillip to the ailing agriculture.

As poverty is the major cause for degradation, major emphasis was on poverty alleviation. Alternative income generation activities for livelihood security were created for forest dependents. About 1.75 lakh forest dependents and poorer sections, especially women, have been benefited through alternate employment generation. Role of women in this programme was given high priority by forming 3891 women's Self Help Groups with 60,000 women in 1367 villages. Extending micro-finance to the forest dependents and rural poor has been a boon to them. As a result, the villagers have protected the forests and are also refraining from the activities detrimental to forest conservation. The quality of life of the villagers was improved by providing community infrastructure through the project and by means of inter and cross-sectoral linkage.

The project gave an unprecedented thrust to Forestry Extension to educate the people and farmers on sustaining the green cover in the State. Fifteen extension and interpretation centres were established to involve farmers in agro-forestry, silvipasture, agriculture, and land management practices in dry and marginal lands. These efforts resulted in increased tree/forest cover outside the forests. Encouraged by the success of the first Phase, the second Phase has been launched from 2005-2006 onwards. Tribals, natural custodians of forest ecosystems, have been given centre stage in the project. Around 1775 sq. km of degraded and degrading forests and tribal forest area will be protected and developed to benefit 800 forest fringe and tribal villages. Poverty alleviation will get greater focus by extending the activities for five years in each village. Research and extension will contribute to the ecosystem protection, conservation and management in technical, institutional, and societal dimensions. Tamilnadu has successfully co-managed its vulnerable ecosystem with the local communities. These efforts will go a long way in restoration of biodiversity and reduction of threat to the native flora. It is heartening to note that the people have turned their attention towards conservation of their local biodiversity, which is vital for their healthy life.

K. P. M. Perrumahl, I.F.S., belongs to the 1978 batch of the Tamil Nadu Cadre. He is a post-graduate in zoology and also a law graduate. He has served in various capacities in the Tamil Nadu Forest Department. He has been involved in the management of forests of both Western and Eastern Ghats, spread over in Madurai, Theni, Ramanathapuram, Dindigul, Trichy, Vellore, Salem, Erode, Coimbatore, and Nilgiris districts. He has wide experience of teaching forestry subjects, having served as Lecturer for four years in the State Forest Service College run by Government of India and as Dean of the erstwhile Southern Forest Rangers College, Coimbatore, for four years. He has served in the Tamil Nadu Tea Plantation Corporation also for four years

as its General Manager. He has the experience of managing in the capacity as Director, Arignar Anna Zoological Park, Vandalur, Chennai. Presently he is the Chief Conservator of Forests in charge of implementing the Tamil Nadu Afforestation Project. He has undergone a four weeks training programme on 'Environmental Impact Assessment for Developmental Projects' in National University of Australia, Canberra. He has translated the Indian Wildlife (Protection) Act of 1972 into Tamil as a book for the use of trainees of forestry training institutes and staff of the Forest Department.

Suggested Reading

Tamilnadu afforestation project funded by Japan Bank for International Cooperation (JBIC). <http://www.tnforests.nic.in/JFM.htm>

Reviving traditional agricultural ecosystems: building on traditional knowledge and wisdom

A. V. BALASUBRAMANIAN

Centre for Indian Knowledge Systems, 30 Gandhi Mandapam Road, Kotturpuram, Chennai 600 085 (Tel: + 91 44 2447 1087 / 2447 5862; Email: ciks@vsnl.com, info@ciks.org)

The Indian sub-continent is situated uniquely and endowed as it were with incredible bounty in terms of natural resources. India commands a total area of about 330 M Ha which is the eighth largest in the world. However, it is remarkable that 3/5th of this area is cultivable. In comparison, in most other available areas of the world the cultivable land is no more than 1/5th and the worlds' average is 1/10th. We have a cultivable area of 160 M Ha which is only behind the US (177 M Ha). The average annual rainfall in India is 105 cm which is the largest in the world for any country of comparable size. USA which is about 2.5 times the area of India receives about the same volume of total water by rain. Most importantly, almost everywhere in India (particularly in the deltas and the river valley regions) it is possible to grow two crops a year and with some effort three crops. There is hardly any other region of the world where this is possible over such a large area. The production as well as productivity of Indian agriculture has been known and admired to be spectacularly high through the ages and has held visitors and travellers in awe for over two millennia.

However, during the course of the past 200 years a series of dislocations and interventions of various kinds and at varying levels has put this system of agriculture under tremendous pressure. About forty years ago, the threat of an imminent famine and possible severe shortage of food made us embark upon a course of agriculture with intense dependence on chemical inputs and fossil fuels. While this indeed helped us to tide over the crisis on a short-term basis a fundamentally different approach is needed if agriculture is to be put on a sound footing on a long-term basis to balance the varied requirements of meeting the food requirements of the human and cattle population, maintaining harmony with the ecosystem and achieving the above building upon traditional knowledge and resources in an optimal and sustainable manner.

In this presentation, I shall try to spell out an approach towards restoration of agricultural ecosystem based on our traditional knowledge, wisdom, and practices. This focuses mainly on some efforts that have been taken up in the Tamilnadu state and various such efforts are afoot also in other parts of India. In terms of building on traditions there are three different aspects that we

may think about namely – knowledge base, human resource base, and material resource base.

In terms of knowledge base, in India we have a rich and extensive tradition of knowledge relating to agriculture which manifests itself at two levels. At one level there is classical / textual knowledge that finds expression in texts of Sanskrit and various other regional languages. At another level, there is tremendous prevalence of folk or traditional knowledge among farmers and various other associated persons including – cowherds, shepherds, tribals, forest dwellers etc. The Indian Council for Agricultural Research (ICAR) recently undertook a programme for a documentation of traditional practices relating to agriculture from various parts of India. This has been published in a series of volumes which shows a tremendous range and depth of knowledge throughout the country. What is even more striking is that a set of selected practices that were considered important (about 111 of them) were put to rigorous scientific test in a series of experiments in agricultural universities, ICAR institutions and KVKs. The results were quite remarkable in as much as about 90% of the practices that were tested were found to be valid and correct as per the assessment. Recently there has also been a large number of popular magazines that are making compilations of such practices and initiating discussions between the farming community and scientists.

At the level of material resource base, India has a stupendous biodiversity of both cultivated crops and medicinal plants. The All India Coordinated Research Programme of Ethnobiology (AICRPE) of the Department of Environment indicated that just the tribal communities of India alone (who constitute about 7% of our population) have a knowledge of about 9500 species of plants. Of these, about 7500 were used for their medicinal properties and about 3,900 were used relating to food. However, in recent years, there has been an alarming reduction of diversity of cultivated crops including cereals, fruits and vegetables. We need to make amends in the light of some devastating crop failures, the world over arising from genetic uniformity.

At our Centre in Tamilnadu we have set up community based seed banks for conservation and propagation of traditional varieties of paddy and vegetables. It has been estimated by our famous Rice Scientist, Dr. Richaria that during the Vedic period India perhaps had about 400,000 varieties of paddy. During his lifetime he was himself able to make a collection of over 20,000 traditional paddy varieties. The tremendous resource base as well as the knowledge base regarding the traditional uses of these varieties can play a central role in the restoration of agricultural ecosystems.

We see that India is uniquely endowed in terms of various advantages with respect to not only the material resource base for agriculture but also the knowledge base. There are significant portions of Indian agriculture which are still by and large organic by default if not by design. Traditional agriculture in India means non chemical organic farming whereas today the term in Europe or US means chemical agriculture. There is also reason to believe that considerations of sustainability and ecofriendliness is something which has been deeply embedded and inherent to our traditional knowledge and practices. It is not an

"afterthought" after the devastation of our land by chemical agriculture. These factors can contribute in a strong and positive manner to the revival of our traditional agricultural ecosystem.

A. V. Balasubramanian obtained his M. Sc. degree in Chemistry from Bangalore University and did a post-M. Sc. diploma in molecular biophysics from the Indian Institute of Science, Bangalore. Later he studied physiology and biophysics at the State University of New York at Stonybrook. Since 1982, he has been involved in work relating to various aspects of traditional Indian sciences and technologies and trying to explore their current relevance and potential. Currently he is the Director of the Centre for Indian Knowledge Systems—an Institution devoted to exploring the contemporary relevance and applications of Indian knowledge systems, particularly in the area of agriculture.

Suggested Reading

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Status of coastal and marine ecosystems and species diversity of India and future perspectives

V. K. MELKANI, I. F. S.

Chief Conservator of Forests and Trust Director, Gulf Of Mannar Biosphere Reserve Trust, Ramanathapuram, Tamilnadu (Tel.: +91 4567 226335; Fax: +91 4567 229 228; Email: gombrt@yahoo.co.in)

All ecosystems and its associated habitats and species are vital for the country's prosperity, survival, and growth. These natural systems provide life support services without which life cannot be imagined and sustained. India is blessed with bounty of natural resources of diverse kinds because of distinct and unique bio-geographic zones from Trans-Himalayan to the Coast and its location at the confluence of three major bio-geographic realms – the Indo-Malayan, the Eurasian, and the Afro-Tropical.

India's coastal and marine environment is vast with about 8000 km long coast line and surrounding coastal waters which encompasses a variety of ecosystems and diversity of species. The marine and coastal biodiversity is not systematically studied and documented, and recorded marine biodiversity, therefore, appear as not so significant at a casual look. The coastal ecosystems are front line protectors of our shores. The 2.02 m sq. km of EEZ and 0.506 m sq. km of continental shelf provide rich marine and fisheries resources, economy, and livelihoods to millions of people residing in coastal areas.

Increasing anthropogenic pressures and growing demands of economy-driven growth has started putting larger and serious threats to the resource capital and its sustainability and conservation. Conservation initiatives to protect and maintain key ecosystems and habitats along the Indian Coasts has begun since eighties and some level of improved protection in these areas have been achieved, but the battle is not fully won.

The nature of threats and its intensity need to be fully understood and remedial measures are taken to reverse the current trends. Orthodox Conservation through mere or absolute protection will not work in coastal areas which are densly populated and highly complex and where fishing as a traditional form of livelihood is in practice and there are multiple uses and users of the areas.

An intense and focused approach for a truly integrated management of coastal and marine regions holds the key for better conservation and sustainable use of resources where all "stakeholders" are sensitized enough to understand, acknowledge and accept the value and need for conservation and accordingly adopt and apply sustainable way of living and resource use and curb their negative interactions with the natural resources. Sustainable fisheries must be

followed and very strictly monitored, without which conservation of biodiversity cannot be achieved. Co-ordination, co-operation and collaboration among all stakeholders of the area will pave the way for knitting the core concerns and ethics of conservation and its mutuality with sustainable use of resources and development. The Gulf of Mannar Biosphere Reserve Trust, a new statutory institution of Government of Tamil Nadu is currently making sincere efforts under GEF – UNDP – GoI – GoTN's collaborated and co funded project on *"Conservation and Sustainable Use of Gulf of Mannar Biosphere Reserve's Coastal Biodiversity"* for securing multisectorial stakeholder's genuine participation and support to successfully achieve integrated management of Gulf of Mannar Biosphere Reserve in Gulf of Mannar region known to harbor marine and coastal biodiversity of global significance.

V. K. Melkani, I. F. S., is currently Chief Conservator of Forests and Director of the Gulf of Mannar Biosphere Reserve Trust. He has extensive experience in forestry and conservation issues in terrestrial and coastal areas in Tamil Nadu. He has served as the Field Director of Kalakad-Mundanthurai Tiger Reserve, where he oversaw an ambitious eco-development programme aimed at enhancing rural livelihoods while augmenting forest regeneration, protection, and biodiversity conservation.

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Conservation and stabilization of sand dunes: experiences from South Poigainallur, Tamil Nadu*

R. BALAKRISHNAN

Panchayat President, South Poigainallur Post, via Velankanni, Nagapattinam District 611111, Tamil Nadu

South Poigainallur is situated about 10 km south of Nagapattinam along the Tamil Nadu coast. The social and economic functioning of South Poigainallur is centered on the village's agriculture-related activities. The total population of South Poigainallur is 4255, with 1410 males, 1434 females, and 1079 children (551 male and 528 female children).

The village has two kinds of lands mainly, that is, lowlands and uplands. The interesting aspect of the lands in South Poigainallur is that almost every piece of land is part lowland and part upland. This is a natural occurrence and the farmers do not try to change it. There is no river or canal irrigation in the village. During the rainy season, the village faces water flooding. The water is therefore channelled through these canals up to the sea. Ponds are dug on each one's own piece of land, and are used for irrigating crops. People use the common ponds known locally as *mandua* when more water is required. There is no discrimination in the usage of these common ponds, and the villagers share in the water equitably. There have also been no conflicts regarding the water of the common ponds.

South Poigainallur is very well known for its sand dunes along the seashore at a height of 30-40 feet. Sand dunes are found on the seashore at a distance of 15 metres from the sea. The height of the sand dunes is about 30-40 feet from the ground level. The dunes start at the northern side of South Poigainallur near Kallar which is ½ km from South Poigainallur and ends near Vailankanni (near Pookara street) and extends to a length of 6.5 kms.

In order to protect crops from the waves and institute soil conservation measures (to prevent deposit of sea sand in their fields) the people erected fences using palm leaves along the seashore and planted palm trees along the fence. The people claim that the high tides brought sand to the shore carried on the waves which was then cast along the fencing lines along the seashore. They are of the view that since sand travels easily on the wind, the accumulation has been easy and the height of the dunes has grown over time. Moreover, the community have observed that during the season of the North winds (Winter season—November and December) a lot of sand accumulates on the seashore. The dunes from time to time were then stabilised by various vegetation of cashew, tamarind, and *Spinifex*. The dunes and this vegetative fencing prevented soil erosion and sand casting

onto the agriculture fields. This is how they claim they have enhanced the formation of the famous sand dunes in their village. They claim that 500 years ago, the height of the sand dunes was only 5-10 feet, whilst now they are 30-40 feet.

The people believe that the sand dunes have protected them from natural disasters such as cyclones and high tides. The dunes have in fact been largely responsible for minimising the number of deaths in the village during the tsunami. The community have resisted the outsiders and prevented digging of sand from the sand dunes by presenting a united front. After the tsunami, the Panchayat passed a resolution to protect the sand dunes and banned outsiders digging sand from the sand dunes.

*Adapted from *Village Level People's Plans—realities, aspirations, challenges—South Poigainallur, Tamil Nadu*, Praxis—Institute for Participatory Practices

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R. Balakrishnan, aged 43, SSLC, is the present President of the South Poigainallur village panchayat. He is affiliated with the PMK (Pattali Makkal Katchi) party. After his studies, he was involved in looking after the family agricultural land. In 1983, an NGO, CASA started activities in the village for village development. They provided training in cotton thread weaving. R. Balakrishnan and his friends were impressed by the welfare activities. Therefore, he along with his friends decided to involve themselves in social welfare activities such as repairing street hand pumps and replacing the street lamps. For example, they collected a fund for establishing a gymnasium. They functioned without a banner however and as an informal group alone. In their leisure time, they discussed the prevalence of poverty and unemployment and the exploitation of the public by the politicians. The youth were guided by V. M. Guru, Balakrishnan's uncle, a member of the Vanniyar Sangam (Vanniyar Association). He is now affiliated with the PMK and since 1984 he contributed a lot for the growth of the PMK in the region and became an influential PMK person in South Poigainallur. In 1994, he became the secretary of Nagai East Region PMK. In 1996, he contested in the village panchayat election for the post of president and won and has served two terms. Although South Poigainallur was also affected by the tsunami albeit less visibly, government officials did not visit the village as it was not affected directly. Since all the efforts of the village to draw Government officials' attention towards the village failed, under the Balakrishnan's leadership, eight camps were organized for free distribution of food to 4500 people. The President contributed generously along with other groceries collected from NGOs. This continued for around 15 days after the tsunami.

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Conservation of sandy beaches and dunes

KARTIK SHANKER[1,2], ROHAN ARTHUR[3], AARTHI SRIDHAR[2] & SUDARSHAN RODRIGUEZ[2]

[1]Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012 (Tel.: +91 80 2334 0985; Email: kshanker@ces.iisc.ernet.in)
[2]Ashoka Trust for Research in Ecology and the Environment, 659, 5th 'A' Main Road, Hebbal, Bangalore 560024 (Tel.: 91 80 23638771)
[3]Nature Conservation Foundation, 3076/5, IV Cross, Gokulam Park, Mysore 570 002 (Tel.: +91 821 2515601).

Description and importance: Coastal offshore and onshore habitats have great significance for the survival of marine and coastal flora and fauna. As an ecotone between the two habitats, beaches are dynamic and subject to a variety of changes. The biota of this region have adapted themselves to diurnal, tidal, lunar, seasonal, and stochastic events in this zone. Any acute or chronic changes in this habitat due to anthropogenic actions can have irreversible negative consequences. In this context, it is important to understand the impact of anthropogenic activities in the coastal zone and how they can be prevented or mitigated.

Sandy beaches are vital coastal systems that occupy a significant part of the coastline. They are habitat for many inter-tidal animals, including crabs, clams, mole crabs, oligochaetes, and other marine invertebrates. Sandy beaches are critical nesting habitats for the world's marine turtles, and four species including the endangered leatherback and hawksbill turtles, nest on Indian shores. The olive ridley turtle has mass nesting sites in Orissa, one of the three rookeries worldwide. Sandy beaches can be narrow strips backed by coastal forest, or wide with large undulating dunes that have a variety of creepers, grasses, and woody species. On the east coast of India, *Ipomea pes-caprae* is a widely distributed creeper, *Spinifex* is the most common grass, and *Pandanus* is a common woody species. Sand dunes can also play a critical role in protecting communities from events such as storm surges.

Natural dynamics of the beaches: Beaches are highly dynamic systems which are subject to seasonal and annual geomorphological changes caused by cyclones, storm surges, longshore currents, and hydrological effects. This can be seen particularly at river mouths where sand bars are frequently accreted and eroded, as has been documented in many sea turtle nesting beaches in Orissa. There is also exchange of sand between the dune and the beach which can be interrupted by anthropogenic processes.

Threats: India has 7,500 km of coastline under 53 coastal districts of 10 maritime states and six union territories. According to the 1991 census, nearly 50% of the country's population inhabit these areas, which has put tremendous pressure on the coastline. Threats on the beach include sand mining, construction of roads and residences, beach armouring, plantations, and ports and jetties. The removal of sand for a variety of reasons, primarily construction, results in the destruction of sandy beaches. Encroachment on the habitat by plantations and human constructions also affects the habitat. While some encroachments like residences, resorts, and roads often disturb the ecosystem, they may not change the geomorphology of the beach. On the other hand, others like plantations, primarily of *Casuarina*, close to the high tide line can considerably change the geomorphology of the beaches and result in erosion. Coastal armoring structures are amongst the biggest threat to sandy beaches; they cause reflection in wave energy, which can increase erosion seaward of these structures. The intensity of long shore currents can be increased, moving sand away from the site more rapidly and in greater quantities. The natural exchange of sand between the dune and the beach is prevented; the wave energy is concentrated at the end of armoring structures, which can exacerbate erosion at adjacent, unarmored beaches. For example, in Kerala, 500 of 600 km of coast is now covered with sea walls. Other onshore construction like ports, harbours, and jetties can have similar effects. Threats in offshore waters such as pollution can also have detrimental effects on sandy beaches, and large scale changes in land use for aquaculture and tourism can destroy these habitats.

Policy: Explicit legal protection is afforded to the Indian coastline by the Coastal Regulation Zone (CRZ) Notification, 1991, issued under the Environment (Protection) Act, 1986. It does this, first, by regulating development on the coast and, second, by explicitly requiring the protection of sand dunes. According to the CRZ Notification, sand mining is a prohibited activity on the mainland coast. Section 2(ix) of the notification prohibits the 'mining of sands, rocks and other substrate materials'. However, various amendments to this notification have allowed for sand mining and other destructive activities. The notification also prohibited the 'dressing or alteration' of sand dunes, hills, and natural features for either beautification or recreation, or landscape changes. Protective features within law have been changed considerably with targeted amendments made to the CRZ framework. Sand mining for construction purposes is one of the significant threats to sandy beaches and dunes. Within its implementation history, committees have been set up to examine the issue of local needs and limits to sand extraction have been prescribed (for the Andaman and Nicobar Islands) but the activity is unregulated and carries on unabated. There has been an overall lack of awareness of the legislation and this has therefore not really resulted in either a change in the resources use pattern or its demand. The CRZ as a protection measure has only been able to outline how the beach resources (present at certain locations) need to be safeguarded. The law is not able to prescribe appropriate or alternative building material, which will ensure that the demand for the resource is kept to a minimum.

While there are many community-based sand dune protection measures, there is no space within existing legislation to promote such conservation or restoration measures. How should legal regimes incorporate local use and protection arrangements? These aspects need closer examination.

Social Aspects: By and large, the fisherfolk community perception of land on the coast stems from their view of the sea – an open access use regime. The same is especially true for sandy beaches and dunes. In fact, the choice of craft such as the catamaran, which is a beach landing craft, is a result of natural factors such as the sea and the shore. Hence, there is general opposition by communities to plantations very close to the shore and beaches. However, there is an absence of an explicit policy and legal environment recognizing aspects of traditional tenure/use, rights and access of local coastal communities, and this has led to a lot of conflicts.

Restoration and recommendations: Sandy beaches and dune ecosystems may be allowed to recover with small amounts of inputs once the habitat has been cleared of adverse influences. Therefore, prophylactic measures work best, and in cases where it is possible, the removal of threats would be the primary strategy. It may be possible to restore beaches using sand trapping (with fences and vegetation). The restoration of coastal vegetation may also be useful, but the appropriate vegetation needs to be planted at particular locations. Though some restoration methods of these systems exist, little can be done when the geomorphology has been completely altered. Plantations and permanent habitations such as resorts, residences, and roads must be carried out only at a sufficient distance from the high tide line.

Kartik Shanker is Faculty at the Centre for Ecological Sciences, Indian Institute of Science and Adjunct Fellow, Ashoka Trust for Research in Ecology and the Environment, Bangalore. He did his PhD on small mammal community ecology at Indian Institute of Science and has since worked on the biology and conservation of sea turtles in India. His coastal and marine programme at ATREE integrates research on natural and social sciences to influence policy and promote action to enhance conservation and livelihoods on the coast. He has started *Kachhapa* and *Indian Ocean Turtle Newsletter* and serves as the editor of the journal, *Conservation and Society*.

Rohan Arthur is a marine biologist working with the Nature Conservation Foundation. His main interests centre around the ecology of coral reef ecosystems, and the uses and meanings they hold for communities dependent on them. Rohan obtained his MSc degree in wildlife science from the Wildlife Institute of India, Dehradun, during which time he studied the coral reefs in the Gulf of Kutch. He later obtained his doctorate from James Cook University, Australia, studying coral reefs and reef fish in the Lakshadweep islands. He has also worked on coral reef systems in the Andaman

Islands, the Gulf of Mannar, and East Africa, and is currently part of an initiative assessing effects of the tsunami on India's east coast.

Aarthi Sridhar is a researcher with a special interest in coastal and marine conservation. She is particularly interested in the functioning of conservation laws and conservation challenges emerging from 'development' on the coast. She is currently with the Coastal and Marine Programme of the Ashoka Trust for Research in Ecology and the Environment (ATREE), Bangalore, India.

Sudarshan Rodriguez has varied interests and has worked in several locations with a range of civil society groups on the Indian coast on marine conservation matters. He is currently the project coordinator for the UNDP Post-Tsunami Environment Initiative. He continues to support several fishworker and NGO groups in their efforts at addressing challenges to sustainable and equitable use of natural resources.

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Science-based and community-centred approach to restore degraded mangrove wetlands

V. SELVAM

M. S. Swaminathan Research Foundation, III Cross Street, Taramani Institutional Area Taramani, Chennai 600 113, India (Email: vselvam45@hotmail.com)

The mangrove wetland forms a dynamic ecotone between land and sea. Mangrove wetlands are unique in terms of its environment, and its plant and animal communities. The distribution of mangrove wetlands is restricted to tropical and subtropical coastlines. They perform a number of protective and productive functions, which ensures ecological security of the coastal areas and livelihood security to the coastal communities. The east and west coast of the mainland of India and Andaman and Nicobar islands are characterized by the presence of well developed mangrove wetlands. According to Forest Survey of India, out of 487,100 ha of the mangrove wetlands of India, nearly 56.7% (275,800 ha) is present along the east coast and 23.5% (114,700 ha) along the west coast and the remaining 19.8% (96,600 ha) is found in the Andaman and Nicobar islands. Though a substantial area of many of the mangroves is in a degraded state, in some of the mangroves, the forested area is increasing due to restoration efforts. One of the reasons for such positive trend is the science-based and community-centred approach developed and demonstrated in recent years in the mangrove wetlands located along the east coast of India and M. S. Swaminathan Research Foundation (MSSRF) played a leading role in this restoration effort.

In the present paper, a case study relating to Pichavaram in Tamil Nadu is presented for a better understanding of the above approach. Pichavaram mangrove wetland is located in the northernmost part of the Cauvery delta. According to the remote sensing data in 1986, the total area of the mangroves within declared forests (Reserved Forests) was about 1,474 ha, out of which nearly 53% of the mangrove forest area (not the wetland area) was in degraded state. It was generally considered by the stakeholders and management agency that use of the resources by the local community is responsible for such large-scale degradation. But ecological studies carried out in the Pichavaram wetland by MSSRF between 1993 and 1995 showed that unscientific management practices followed in the past are the main causes of degradation.

In the Pichavaram mangrove wetland, a system of management called "coupe-system" was followed from 1935 to 1970. Under this system, healthy mangrove forest was clear-felled by government agencies in coupes by rotation in every 20 years for revenue generation. This triggered a chain reaction, leading to development of hyper-saline conditions in the coupe-felled area, and preventing

natural regeneration of mangroves. Since nearly 80% of the volume of the mangrove soil is made up of water, exposure of this soil due to clear-felling caused evaporation of soil water. This in turn led to subsidence of sediment in the clear-felled area, on account of which the topography of the coupe-felled area became trough shaped. As a result, tidal water entering into these "troughs" during high tide became stagnant; evaporation of stagnant tidal water led to increase in salinity, which is lethal to any mangrove plant. An estimate indicates that coupe-felling is responsible for nearly 65% of degradation in the Pichavaram mangroves. On the basis of the above observation, a restoration technique, which is now popularly called as "canal method of restoration" was developed and demonstrated successfully in a small area. At the end of demonstration, a number of questions were raised such as how to sustain the restoration efforts and how to avoid social pressure on restored areas. As an answer to the above questions, a Joint Mangrove Management approach, which is mainly centred on the local user community, was developed and demonstrated in seven mangrove wetlands along the east coast of India. This approach was evaluated by the Ministry of Environment and Forests, Government of India, and considered as the best available approach and included in the National Mangrove Action Plan. Now this approach is followed by various stakeholders in restoring degraded mangrove wetlands, which has resulted in substantial increase in the forested areas of mangrove wetlands both along the east and west coasts.

V. Selvam obtained his MSc in Marine Biology and Oceanography from Annamalai University during 1980-1982. Following this he obtained his PhD in mangrove ecology from the University of Madras in 1992. From 1992 till date, he has worked in the M. S. Swaminathan Research Foundation (MSSRF) in various positions, dealing with conservation and management of mangrove wetlands. He is currently functioning as Programme Director, Coastal Systems Research Division of MSSRF. He has nearly 23 years of experience in the management of mangrove wetlands. His major contribution is in the development and demonstration of a science-based and community-centred approach to restore and sustain mangrove wetlands. He is widely travelled and serves as an advisor to the Governments of Sri Lanka, Malaysia, and Maldives on mangrove restoration, conservation, and management.

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Restoration of coastal ecosystems—need and strategies

J. K. PATTERSON EDWARD

Suganthi Devadason Marine Research Institute, 44-Beach Road, Tuticorin – 628 001, Tamil Nadu, India *(Tel: +91 461 2336487 / 2323007; Email: edwardjkpatterson@yahoo.co.in)*

Coastal ecosystems are areas of rich biological diversity as they support various forms of fauna and flora. About 90% of the global fish catch and 80% of all known marine fish species are found in the coastal ecosystems. Various important and productive ecosystems such as the coral reefs, seagrasses, mangroves, and estuaries, which occupy the coastal areas, are the key sites of the coastal marine lives. These ecosystems not only provide a sanctuary to myriad marine life but also play a key role in protecting the coastline from erosion and other natural calamities. The relevance of these ecosystems is in the limelight at present after the 2004 Indian Ocean tsunami. They also form the main habitats for the reproduction and growth of many economically and ecologically important fish species.

The coastal ecosystems are already experiencing multiple problems and many coastal resources are in highly stressed conditions due to the threats mainly from humans and nature. The various human activities in and around the seas have led to serious degradation of the coral reefs, mangroves, seagrasses, and estuarine ecosystems. Population growth, unsustainable and destructive resource harvest practices, and land-based domestic and industrial pollution are some of the threats that vastly damage the coastal habitats and biological resources. Global warming, coastal erosion, fresh water run-off, predators, diseases, natural disasters such as cyclones, storms, and tsunamis also add considerable stress. At the present level of industrial revolution, it is expected that the global warming would cause greater damage in the near future.

Coastal areas are important and most preferred human settlement sites since ancient time and half of the world's population live within a distance of less than 200 km from the coast. It is expected that the population of the coastal zone would become almost double within 20-30 years. Coastal zone is also considered as the vital ecological bridge between the terrestrial and aquatic ecosystems and therefore their restoration and conservation are essential to maintain the biodiversity and ecological balance. The damage / stress to these ecosystems would lead to the decline / extinction of many valuable biological resources. A number of lessons were learnt from the 2004 Indian Ocean Tsunami with respect to coastal ecosystems and its resources. Proper long-term action plan with an integrated approach in restoration and conservation of coastal ecosystems would

not only help in the promotion of sustained livelihood but also in the effective coastal protection.

J. K. Patterson Edward is the Director of the Suganthi Devadason Marine Research Institute Tuticorin, Tamil Nadu. He has a PhD degree in marine biology and his interests span a range of subjects in marine biology and conservation. These include biological oceanography, marine ecology, fisheries, aquaculture, policy, law, economics, management, marine and coastal resource conservation and management, molluscs, coral reef restoration, and community-based conservation. In the Gulf of Mannar Marine Biosphere Reserve in Bay of Bengal, Southeast coast of India, he continues research work on marine and coastal resource management, marine mollusc biodiversity and culture, and socio-economics.

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Overview: conservation and restoration for management of marine and coastal areas

ROHAN ARTHUR[1] & KARTIK SHANKER[2]

[1]Nature Conservation Foundation, 3076/5, IV Cross, Gokulam Park, Mysore 570 002 (Tel.: +91 821 2515601; Email: rohan@ncf-india.org).
[2]Ashoka Trust for Research in Ecology and the Environment, 659, 5th 'A' Main Road, Hebbal, Bangalore 560024 (Tel.: 91 80 23638771)

Coastal and nearshore marine ecosystems have several unique characters that determine how they behave in the face of disturbance and influence their amenability to restoration efforts. These ecosystems exist in a relatively narrow band at the interface between land and sea, extending within a few hundreds of metres landward from the shore, and to a depth of around 60 m (the approximate boundary of the photic zone) offshore. Although narrow, this strip is a series of rapidly changing environmental conditions. Coastal and nearshore systems are subject to considerable natural flux and extremes in environmental condition. This environment is also characterised by frequent pulse disturbance events such as extreme high and low tides, storm surges and cyclones. Events such as these often have catastrophic consequences, yet these ecosystems appear remarkably resilient in the face of these events. The linear spatial geometry of many coastal habitats also has significant implications both in determining patterns of disturbance and fragmentation, as well as in shaping connectivity and recruitment patterns. The recovery of these ecosystems after disturbance events is often highly dependent on current patterns and the integrity of upstream source populations.

Coastal environments in the developing tropics also house much higher human densities than the hinterland, and resource dependencies on these systems are higher than elsewhere. Direct human use, and the indirect fallout of human presence on the coast (coastal pollution, developmental pressures, etc.), puts a further burden on coastal environments, and additionally challenges the restoring of these ecosystems once they have been degraded.

Despite the considerable challenges, the restoration of coastal and nearshore marine environments is widely practiced, and with mixed success. Restoration efforts have been attempted under a range of conditions. Often restoration follows the chronic loss of the ecosystem due to one or more anthropogenic influences, either direct or indirect (pollution, fuelwood extraction, trampling etc.). Large natural disturbance events such as cyclones, tsunamis, and mass bleaching, may also be valid reasons to consider restoration efforts. More directly, restoration has followed pulse anthropogenic events such as major ship

groundings or dredging activity, and they often employ a 'polluter pays' principle, to ensure that the parties responsible for the event take responsibility for its restoration. Most relevant to the current scenario in Tamil Nadu, restoration has been promulgated as an effective strategy to promote coastal resilience, and as bio-shields against the vagaries of disturbance events.

Within the Indian context, perhaps the ecosystem most readily amenable for restoration is mangroves, perhaps because it employs tools closer to traditional silviculture than for most other coastal and nearshore ecosystems. Both forest department and non-governmental organisations have taken up mangrove plantation exercises in degraded mangrove stands, and a well-established body of knowledge is now accumulating on the best practices for mangrove restoration efforts. Although few attempts have been made in restoring other coastal ecosystems such as coral reefs and coastal dunes, not enough of these have been attempted to evaluate their relative success or failure. No serious attempts have been made thus far (as far as this author is aware) of restoring degraded seagrass ecosystems.

It is important to stress that coastal ecosystem restoration should be seen as just one in a suite of tools available for better coastal management. Ecosystem restoration of nearshore and coastal ecosystems should, in best practice, be at the far end of an escalating scale of approaches, undertaken when most other measures have failed, not as the first response to the problem of coastal and marine ecosystem degradation. For one, restoration in most marine and coastal systems is an extremely expensive and labour-intensive activity, whose benefits from an ecological perspective are of uncertain merit. Besides, these systems are often better able to recover after catastrophic declines than many terrestrial systems, as long as the factors that caused their degradation are dealt with effectively. Managing these causal agents of degradation while allowing the ecosystem to recover may often be the most ecologically and economically feasible option for these systems, particularly when, as in the case of coral reefs or seagrasses, we are as yet unsure if we can ever hope to replicate or restore the same ecological functioning with our recovery efforts.

The post-tsunami context: soft engineering options and coastal vulnerability

The restoration of coastal and marine environments has become particularly important along the Tamil Nadu coastline after the tsunami of 2004. In the aftermath of the tsunami, the integrity of coastal ecosystems appears to have become firmly equated in the minds of policy makers and practitioners with coastal resilience. While the jury is still out on how much prophylaxis coastal vegetation provided against the onslaught of the tsunami, both government and multilateral organisations are leading the drive in pushing for ecosystem restoration activities all along the coast. Despite its dubious reasoning, this push could still be a valid means of exploiting otherwise limiting resources and commitment to ensuring that these crucial nearshore ecosystems are afforded vital protection. The trend is nonetheless worrying, because it belies a rather limited understanding of coastal management, resorting to naïve soft engineering

solutions to problems whose root often lies elsewhere. Even more worrying is a trend towards large-scale landscape transformation such as the monoculture plantations of *Casuarina* that are rapidly taking over the coastline under the banner of coastal bio-shields. Activities like these need much more critical evaluation before they are promoted as panaceas for resilient coastlines.

Rohan Arthur is a marine biologist working with the Nature Conservation Foundation. His main interests centre around the ecology of coral reef ecosystems, and the uses and meanings they hold for communities dependent on them. Rohan obtained his MSc degree in wildlife science from the Wildlife Institute of India, Dehradun, during which time he studied the coral reefs in the Gulf of Kutch. He later obtained his doctorate from James Cook University, Australia, studying coral reefs and reef fish in the Lakshadweep islands. He has also worked on coral reef systems in the Andaman Islands, the Gulf of Mannar, and East Africa, and is currently part of an initiative assessing effects of the tsunami on India's east coast.

Kartik Shanker is Faculty at the Centre for Ecological Sciences, Indian Institute of Science and Adjunct Fellow, Ashoka Trust for Research in Ecology and the Environment, Bangalore. He did his PhD on small mammal community ecology at Indian Institute of Science and has since worked on the biology and conservation of sea turtles in India. His coastal and marine programme at ATREE integrates research on natural and social sciences to influence policy and promote action to enhance conservation and livelihoods on the coast. He has started *Kachhapa* and *Indian Ocean Turtle Newsletter* and serves as the editor of the journal, *Conservation and Society*.

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The restoration of the tropical dry evergreen forest ecologically and socially

PAUL BLANCHFLOWER

Auroville Botanical Gardens, Auroville 605 101, Tamil Nadu (*Tel.: 0413 2623101; Email: botanical@auroville.org.in)*

Introduction

History of Auroville's connection with tropical dry evergreen forest (TDEF)

The international township of Auroville is situated in Tamil Nadu, 12km north of Puducherry. It was begun in 1968 as a project of the Mother, with an aspiration of continuing the work of Sri Aurobindo. It is an experiment in Human Unity. The land, which was designated for the project was initially a wasteland. After the efforts of the first settlers it has been transformed into a forested land with the inherent benefits for the inhabitants. As the process continued it was refined, which led to an interest in the indigenous forest of the area.

The reasons for promoting the restoration of the TDEF

Understanding the ecological processes

The indigenous vegetation of an area is the direct expression of the physical environment that has been influenced by geological history. The vegetation is adapted to the long-term rainfall patterns, to the soils, to the temperature regime. The constituent species represent the families and genera that have had access to the area over the geological epochs. Thus when we understand the vegetation we can understand much about the environment past and present, it gives us clues to follow when making management decisions about land use and other related issues such as water management and drainage. In other words we can say that indigenous plant systems have a wisdom, which can be drawn upon if we can recognize the vegetation.

What is the purpose of our actions?

Betterment of human society: protection or development

Our actions are either related to our own betterment or to helping create and sustain the social fabric of human society. It seems that human development is creating an imbalance in the environment at present; therefore it is our responsibility as custodians of the natural resources to find ways to help protect society from the consequences of these actions and then to find ways in which to educate and modify the way in which society is relating to the natural world.

Creating a relationship between people and the forest

If we are concerned with the protection of the forest resources then we must for a long-term solution find ways of creating a relationship between the people and the forest that is mutually beneficial. One, in which the local people feel that their needs are being met and, within which, the forest is not diminishing but actually flourishing.

Restoration and regeneration

Beginning with the first tree nursery around 1973, efforts to raise and plant trees led to the re-greening of the barren landscape around Auroville. Over 1500 acres had developed tree cover in the 1980s, with successful establishment of the exotic *Acacia auriculiformis* tree, in particular. With time, as birds and mammals recolonised, Auroville carried out surveys in remnant tropical dry evergreen forests, including secondary forests, in the region, cataloguing native plant communities including around 1130 species of angiosperms. With *A. auriculiformis* well established, it was the right time for under planting with native TDEF species that grow in the shade. Over the next ten years vast areas of Auroville's 1000 hectares of greenbelt were transformed into an emerging ecosystem of the TDEF. Over 230 species of woody plants, trees, shrubs, lianas, as well as forest floor dwelling bulbs and epiphytic orchids were propagated in the nurseries and transported out into the forests. Each year 30-50,000 seedlings are planted out into the forests. It continues to be a work of passion for many of the people, to provide a secure home to a forest that is beautiful in its pristine state.

A role for the forest in the next decade

Habitat and environment in the context of global warming

In addition to the role of providing natural forest cover, habitat for wildlife, ground water recharge, minor forest products and the raw materials for traditional health care systems the TDEF will have other roles to play in the future.

The TDEF is a forest that is by nature conservative, adapted to a climate zone that is highly variable. The rainfall pattern is never the same from one year to the next. Thus if we are to enter into a period of climate variation and shift, the plants of the TDEF will be adapted to deal with these fluctuations. This climate instability coupled with diminishing natural resources such as ground water indicate that the species of the TDEF will have a role to play in environmental amelioration.

It is not only in the forest areas where the plants of the TDEF will have a role to play. In urban amenity plantings, in landscaping projects for hotels and businesses, and in private gardens the species have a service that they can offer. They are evergreen throughout the year, depending only on precipitation, thus they offer sustainable solutions for gardens, compounds and parks, with the additional feature of supporting a wide variety of birds and insects.

Paul Blanchflower graduated from Edinburgh University in 1990 with a degree in Ecological science. He arrived in India in the following year and has remained there ever since, in Auroville, involved in the restoration of the tropical dry evergreen forest. He is Director of the Auroville Botanical Gardens.

Suggested Reading

Blanchflower, P. 2003. Some notes on the tropical dry evergreen forest of south India. Unpublished report, Auroville, India.

Blanchflower, P. 2005. Restoration of tropical dry evergreen forest of Peninsular India. *Biodiversity* **6(3):** 17-24.

When and where do we need ecological restoration? An assessment from tropical dry forests

M. D. MADHUSUDAN, S. BAGCHI & A. E. PRASAD

Nature Conservation Foundation, 3076/5, IV Cross, Gokulam Park, Mysore 570002, India. *(Tel.: +91 821 2515601; Email: mdm@ncf-india.org)*

In 1988, ecologist Dan Janzen called tropical dry forests 'the most endangered major tropical ecosystem'. While the superlative itself may be challenged, the fact remains that these ecosystems, once believed to cover about 40% of the earth's tropics, have dwindled significantly from conversion to secondary forests, savannas, grasslands, and agriculture. Although tropical dry forests still dominate the Indian Peninsula, the structure, composition, function, and dynamics of these ecosystems remain poorly understood. At the same time, India's dry forests and their fauna today face a growing array of threats, ranging from livelihood-based pressures of fuelwood and fodder extraction, to the diversion of these habitats to a variety of commercial, industrial, and development uses. With little scientific research aimed at understanding the impact of these threats on ecosystem-level patterns and processes, conservation efforts too have rarely gone beyond affording nominal protection to these ecosystems. As ecological restoration gains ground as a relatively newer approach to ecosystem conservation, there is need to review our knowledge of dry forest ecosystems, the threats they face, and assess how ecological restoration relates to existing approaches of conserving these ecosystems.

In our presentation, we first describe intrinsic characteristics of dry forests that set them apart from other forest ecosystems, identify extrinsic threats to them, and review prevailing practices of managing and conserving these ecosystems. The quantum and temporal distribution of rainfall is the dominant force shaping the ecology of dry forest ecosystems. Besides marked seasonal patterns, these ecosystems are also characterized by wide inter-annual variations in rainfall regimes. Structurally, compared with wet forests, dry forests have lower species richness, lower canopy height and vertical stratification, and greater presence of plants in the understorey and ground-layer. In functional terms, they show lower levels of primary productivity, lower rates and greater periodicity of tree growth, and tend to show greater seasonality in reproductive phenology. Successionally, dry forests, while showing greater resilience, are more vulnerable to disturbance, and are governed by fundamentally different regeneration processes involving high-longevity soil seed-banks and a greater role for coppicing. Dry forest ecosystems have also been identified as life-zones that are significantly preferred by humans and hence, under far greater human

impact. Their short stature have perhaps made it easier to clear dry forests, and their openness and availability of ground vegetation make them more suitable for livestock. Low moisture levels have also made possible the use of fire as a significant tool of habitat alteration. Human production systems in the dry forest zone are mostly extensive and have evolved to combat environmental uncertainty, unlike humid zones where intensification of land use appears more frequent. As a result, chronic habitat degradation is seen more frequently than the wholesale habitat loss and fragmentation, although we still lack a systematic understanding of these patterns. In India, with most of this ecosystem under state ownership, they have historically been worked intensively for timber production and other revenue generation (e. g., NTFP, tourism). Today, even in the context of protected areas, where many of the chronic pressures of anthropogenic resource use are suppressed, there is often intensive management (creation and maintenance of view lines, check dams, roads for tourism, and managed fire regimes), often with little understanding of its impacts on the ecosystem itself.

Against this backdrop, we attempt to locate ecological restoration as a management-intensive approach in a range of conservation options beginning with simple preservation. Further, we discuss the potential role for ecological restoration in relation to these other conservation approaches, and attempt to identify critical information gaps in our knowledge of dry forest ecosystems. These include, for instance, understanding the resistance and resilience of these ecosystems in the context of human use and management practices, and comprehending the process and trajectories of secondary succession from degraded to mature formations in relation to seasonality, environmental stochasticity, and anthropogenic use. Only with a better appreciation of these factors can we plough in strategies such as ecological restoration to make effective contributions to the conservation of these threatened ecosystems.

M. D. Madhusudan. I am interested in understanding the ecological and social aspects of human activities that impinge on large wild organisms. I am also concerned about how such knowledge can be employed effectively to mobilize conservation action and change on the ground. Besides this, my academic interests include biology of human-wildlife conflicts; ecology of large herbivores and carnivores; interface of conservation science with society, economy and politics; people-and-parks issues; alternate models of management of wildlife protected areas; and conservation issues in the tropics, particularly, the South and South-east Asian region. My current interests focus on: i) assessments of human impact on large mammals, ii) the population dynamics, behaviour and conservation of the Asian elephant and gaur, and iii) using historical and ecological data in understanding the drivers of distributional change for select large mammals and birds in the Western Ghats.

I carried out my doctoral work at the National Institute of Advanced Studies and my PhD thesis mainly focused on the ecological impacts of two important human activities—hunting and livestock grazing—on large mammals in the tropical forests of Karnataka in southern India. It also examined the socio-cultural and economic drivers

of these activities and described how they determine the nature and extent of human impacts on wildlife. Earlier, in 1995, I graduated with a Master's degree from the Wildlife Institute of India during which I studied sexual segregation in the Nilgiri tahr, a wild goat, in Eravikulam National Park. I have also worked with my colleagues at NCF on other projects including experimental models of participatory conservation in the Trans-Himalaya, exploration of the high altitude regions of Arunachal Pradesh, studies of human-elephant conflict in the Anamalai Hills, and developing the curriculum for a graduate program in wildlife biology and conservation in addition to my own field research and conservation projects. In 1996, I co-founded NCF, and am jointly responsible for managing it.

Sumanta Bagchi is currently doing his PhD from Syracuse University, USA, carrying out research in the Trans-Himalayan high altitudes. He completed his Master's in wildlife science from the Wildlife Institute of India. His research interests are in the field of conservation of large mammalian herbivores and their predators. He has nearly a decade of experience and understanding of the dry forests of western and southern India, and the high altitude rangelands of north India.

***Ayesha* Prasad** joined the Nature Conservation Foundation in July 2005 to work with M. D. Madhusudan researching disturbance and its impacts on large mammals and their habitats. She is currently doing her doctoral research from SUNY college of Environment Science and Forestry and NCF on the impacts of livestock grazing and weed invasion (particularly, the weed *Lantana camara*) on vegetation, herbivores, and carnivores in Bandipur National Park.

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Khurana, E. & Singh, J. S. 2001. Ecology of seed and seedling growth for conservation and restoration of tropical dry forest: a review. *Environmental Conservation* **28**: 39–52.

Murphy, P. G. & Lugo, A. E. 1986. Ecology of tropical dry forest. *Annual Review of Ecology and Systematics* **17**: 67-88.

Skoglund, J. 1992. Role of seed banks in vegetation dynamics and restoration of dry tropical ecosystems. *Journal of Vegetation Science* **3**: 357-360.

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Ecological restoration in a fragmented rainforest landscape in the Anamalai hills

DIVYA MUDAPPA & T. R. SHANKAR RAMAN

Nature Conservation Foundation, 3076/5, IV Cross, Gokulam Park, Mysore 570 002
Rainforest Restoration Research Station, 8/364 Cooperative Colony, Valparai 642 127, Tamil Nadu (Tel: +91 4253 221527; Email: podocarp@vsnl.net)

Tropical rainforests are complex ecosystems characterised by multi-tiered forest structure, high canopy closure, high species diversity and endemism, and intricate plant-animal interactions. Rainforests in the Western Ghats, a hotspot of biological diversity, shelter a large fraction of the region's diversity and endemic species. Historical fragmentation and a current annual deforestation rate of 1.2% in the Western Ghats have resulted in a human-dominated landscape of plantations, agriculture, and developed areas. Remnant rainforests occur mostly as embedded fragments critically important as biodiversity refuges and animal corridors in such fragmented landscapes. In many areas, continuing threats of conversion and degradation necessitate restoration interventions in addition to conventional protection.

Although many degraded areas, particularly within less-disturbed and larger forest tracts, may recover naturally with protection, sites that are isolated or face chronic disturbances may need carefully planned interventions for restoration. Rainforest restoration sites may be selected and prioritised based on site conditions and specific conservation goals (Table).

What kind of sites need restoration?	**Priorities for restoration in the landscape**
Sites with:	*Sites that are:*
• heavy infestation of weeds, vines or grasses arresting natural succession	• habitats of particular threatened or endemic species
• depleted soil seed bank due to historical disturbance such as fire, mining, grazing	• watersheds along streams or river courses
• seed-producing parent trees being locally extinct, as in isolated fragments	• degraded along the edges of national parks, sanctuaries, or reserved forests
• monoculture and commercial plantations	• isolated fragments adjoining plantations
• settlements, plantations, or other land-uses that are now abandoned	• corridors linking forest fragments
• lost or reduced soil nutrients and symbiotic mycorrhizal fungal populations	• along linear disturbances such as roads, powerline clearings, and firelines
• large open areas due to clear-felling, mining, landslides, fires	• wildlife habitats in the landscape (shade coffee, cardamom, & vanilla plantations)

Sites that should *not* be targeted for restoration include areas (such as small gaps) within larger tracts of forests that have high potential for natural recovery and have a near-complete representation of native biodiversity in the surrounding landscape. Species *not* to be planted include exotics (even if a particular species is used by wildlife), although existing exotic trees/plantations may serve as nurse trees for recovery of rainforest. The method of choice is to use mixed native species planting following the *maximum diversity* and/or *framework species methods.* Selected species need to be restricted to those recorded, historically or currently, from relatively undisturbed benchmark sites within the same vegetation type, altitude range, and in a 15-20 km radius of the restoration site.

On private lands in the Valparai plateau, Anamalai hills, we established restoration sites along degraded edge of continuous rainforest and within three rainforest fragments (5, 19, and 100 ha) on private lands belonging to Tea Estates India Limited and Parry Agro Industries Limited. These sites represented varying levels of degradation and canopy cover such as open meadow, sites with dense *Lantana camara* invasion and open canopy, abandoned exotic tree plantations (*Eucalyptus grandis* and *Maesopsis eminii*), and sites with mixed native and exotic tree canopy. Rainforest species for planting are being raised in a nursery at Injipara using seeds fallen on roads and trails passing through forests and forest-plantation edges. Seeds are not collected from forest interiors to minimise disturbance to natural regeneration processes. The nursery presently holds around 30,000 seedlings of 80 rainforest species.

Between 2000 and 2006, we planted annually during the south-west monsoon, 11,582 nursery-raised seedlings of around 130 rainforest plant species (mainly trees, and a few lianas and shrubs) in restoration sites. In addition, in order to replace exotic shade trees with native species, 6,200 seedlings of around 30 rainforest tree species were planted as shade trees in coffee, vanilla, and tea plantations belonging to Tata Coffee Ltd, Parry Agro Ltd, UPASI, and BBTC Ltd. Seedlings monitored at six-monthly intervals showed survival rates over a two-year period of between 34.4% and 90.3% under different site conditions. Seedling survival was higher in sites with complete weed removal as against partial removal along planting lines. Survival was also higher in open meadow and under shade than in sites that earlier had dense weed invasion. A majority of species showed survival rates greater than 50% after two years. Small seedlings and wildlings showed poor survival and growth. Older and hardened seedlings (2-5 years old and 60-120 cm tall) raised from seeds showed higher survival.

Overall, our experience indicates that a large diversity of mature rainforest species are suitable for restoration of degraded rainforest sites ranging from open weedy sites to those with a canopy of exotic trees such as *Eucalyptus grandis* and *Maesopsis eminii*. Planting a large proportion of mature seedlings, and protection from fire and grazing, are necessary for such restoration efforts. Retaining regenerating native species during weed clearing operations was crucial for rapid re-establishment of a first layer of canopy to shade-out weeds and enhance survival of shade-tolerant rainforest seedlings. In a fragmented landscape, there is also a high potential to use native rainforest species as shade

trees in plantations in the matrix surrounding fragments. In addition, economically important rainforest species (e.g., *Canarium strictum, Cinnamomum spp., Mysristica dactyloides, Elaeocarpus spp., Calamus spp.)* can be grown to provide supplementary resources for commercial plantations and tribal communities living in the forests, to minimise dependence on wild harvests.

Divya Mudappa is a scientist at the Nature Conservation Foundation, Mysore, currently engaged in mammal conservation and rainforest restoration projects in the Anamalai hills, Western Ghats. She holds a Master's degree in Ecology from Pondicherry University and a doctorate in Conservation Biology from Bharathiar University and the Wildlife Institute of India. She has studied hornbills, rainforest plants, small mammals and carnivores, and Asian elephants. Her interests are in the fields of plant-animal interactions, conservation biology, and restoration ecology in tropical rainforests.

T. R. Shankar Raman is a scientist at the Nature Conservation Foundation, Mysore. He is involved in projects on rainforest restoration and bird communities in the Anamalai hills, Western Ghats. He holds a Master's degree in Wildlife Science from the Wildlife Institute of India and a doctorate from the Indian Institute of Science. He has carried out studies on deer in southern India and on birds and mammals in tropical rainforests of northeast and southwest India. His interests are in rainforest conservation, restoration, and monitoring.

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Lamb, D., Erskine, P. D., & Parrotta, J. A. 2005. Restoration of degraded tropical forest landscapes. *Science* 310: 1628-1632. Supporting Online Material: www.sciencemag.org/cgi/content/full/310/5754/1628/DC1

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Changing priorities in the management of the shola-grassland landscape

BOB STEWART & TANYA BALCAR

Vattakanal Conservation Trust, P. B. 109, Kodaikanal 624 101 (Email: litsca@vsnl.com)

The once extensive shola-grassland ecosystem found above 1500 m, sometimes described as "cloud forest", is now confined to a few pockets totalling c. 400 sq. km of the southern Western Ghats, mainly in the Anamalais, Nilgiris, and Palni Hills. The rest has been converted to tea, potato, or industrial timber plantations. Much of what remains of the grasslands is now seriously threatened by exotic plant invasion and the attendant weedy growth of native *Rubus* species. Invasives include plantation species especially *Acacia mearnsii* (wattle). The spread of wattle is accompanied by the establishment of *Rubus* species that form thickets when the wattle is harvested.

There is no official action plan for the systematic control or eradication of these threats to the grasslands. These grasslands constitute a complex highly diverse plant community which in turn supports a wide range of fauna from insects through to iconic large mammals such as Nilgiri tahr and tiger. With the sholas they constitute one of the world's rarest, most biodiverse and spectacular of landscapes.

Where the grassland has been destroyed by industrial timber plantations, streams and marshes have dried out. This water that once fed into perennial streams that supported lowland agriculture and generated electricity is all but gone. The crisis in the water regime of the Palni plateau can be observed at Berijam Lake that supplies drinking water to Theni District. Its marshlands dry out after the monsoon and marsh vegetation can be seen advancing into what were previously deep waters.

Attempts by various authorities to address the water crisis of the plateaus have recently been instigated in the Nilgiri and Palni Hills. These are costly engineering works, namely concrete check dams across streamlets and dried out marshes. In the Palnis most of these check dams have been built over granite bedrock, allowing for little percolation of water. Another instance in the Nilgiris is the fencing of an extensive dying wetland. None of these actions address the underlying ecological realities (industrial plantations) that caused the water bodies to die.

A further development noted since February 2005 has been the number of wattle trees experiencing die-back and death, a process that intensified during the next dry season of 2006. In our opinion the water table of the Upper Palnis is all

but destroyed and cannot replenish itself in the face of the enormous demand posed by the millions of fast growing plantation species.

The Government has followed a progressive policy of reafforestation with native species for around a decade. Ourselves, long committed to the raising and planting of shola trees, we now however say that in the context of the ongoing dynamics in this particular landscape the policy is not appropriate. Huge numbers of nursery raised seedlings are planted at great cost. Since the last ten years it is clear to conservationists and foresters alike that these plantings have made little impact on the underlying ecological processes. Year after year these highly exposed, slow growing seedlings are lost. Significantly, they are never planted to help restore existing sholas. These plantings do sometimes survive where there are already lakhs of self-sown seedlings, which have established under the cover of plantation species. Augmenting this vast "natural" spread of the shola is simply a waste of resources.

Elsewhere the Forest Department has embarked on some rehabilitation processes, under the jurisdiction of several District Forest Officers, with different levels of application and interest. Despite the haphazard approach to these rehabilitations, they point to the real possibility of grassland restoration, especially with NGO and community participation. Here the notion of *initial floristic community* or IFC becomes relevant, which is a development of the classical successional theory, but recognises that those plants that get established initially, following disturbance, largely dictate the course of succession. In our case, after coupe-felling, we witness mainly an IFC of exotic invasives and native *Rubus* succeeding to a weedy climax. Otherwise, native carpet forming grasses such as *Digitaria wallichiana* are often the first to emerge, thereby restricting or smothering the emergence of weeds. This natural process can be encouraged thereby propelling the succession in a desirable direction. Removal of *Rubus* species is easy during the early months of succession.

In some instances, the conversion of grassland to plantation and hence to shola as described above is so advanced that we are witness to the emergence of a *novel* or *emerging ecosystem* (Hobbs *et al.* 2006) that has gone beyond a threshold where full restoration (return to grassland) would be practical. We appeal for a scientific overview of the landscape in all its dynamic complexity. Moreover, we appeal for a review of the Forest Department budget allocation that addresses the processes we have described and recognises the importance of grassland restoration. We advocate a future strategy of restoration of ancient sholas, restoration of grasslands, and a middle ground where the native and exotic with some manipulation can evolve into a healthy novel ecosystem. Regarding water security (natural capital, Aronson *et al.* 2006) the restoration of important catchment areas such as Berijam are very doable. Another very practical restoration of wildlife habitat is that of the Palnis southern crest, once the habitat of the Nilgiri tahr, now dominated by exotics and subject to frequent fires.

Bob Stewart & Tanya Balcar. We are British citizens whilst still in our twenties visited India in 1984-85. During that visit we sojourned to a mountainside hamlet near Kodaikanal and discovered the Pambar and Vattakanal Sholas. On our return there in 1986 our initial enchantment turned to disillusion as we began to realize how quickly the sholas were degrading from a wide spectrum of human induced pressures. In that year we decided to try to do something to help and so began our twenty year engagement with the shola-grassland ecosystem, a voyage of discovery that continues today as we examine the novelties, vagaries and variations of our sedges and grasses. Our main scientific work – data on germination and cultivation of c. 250 shola species was published as an appendix to the *Flora of the Palni Hills* (Fr. K. M. Matthew, 1999). We are currently adding to this data and compiling long term biographies of c. 70 shola tree species. We have prepared several restoration proposals for the Nilgiris and Palnis for the future.

Vattakanal Conservation Trust: The founding members of the Trust, which was founded in 2001, formerly established a tree nursery in 1989. Its purpose was to supply local communities with utility tree species so that they need not predate upon the nearby Pambar and Vattakanal Sholas that were rapidly degrading. With community involvement and parallel community development we managed to reverse this degradation and began to engage with the Forest Department and the Anglade Institute of Natural History, then under the directorship of the late Fr. K. M. Matthew.

In recent years, the focus of the Trust has turned towards the higher shola-grasslands, most of which has been converted to tea, potato, or industrial timber plantation. We now advocate grassland conservation/restoration in the name of biodiversity, water security, and for its unique cultural and aesthetic value. We look to the Forest Department as our main collaborator and ally in achieving these. We also advocate, with the cooperation of others, the founding of a school of restoration ecology to facilitate the practice of ecological restoration.

The Trust maintains two nurseries, one focused on shola trees, the other on grassland species. We are currently engaged in the active restoration of Pambar Shola, working in association with the Forest Department.

Suggested Reading

Aronson, J., Clewell, A. F., Blignaut, J. N., & Miltone, S. J. 2006. Ecological restoration: a new frontier for nature conservation and economics. *Journal for Nature Conservation* **14**: 135-139.

Hobbs, R. J., Arico, S., Aronson, J. & 15 others. 2006. Novel ecosystems: theoretical and management aspects of the new ecological world order. *Global Ecology and Biogeography* **15:** 1-7.

Samra, J. S., Sikka, A. K., & Sharda, V. N. 2001. Hydrological implications of planting bluegum in natural shola and grassland watersheds of Southern India. Pages 338-343 in D. E. Stott, R. H. Mohtar and G. C. Steinhardt (editors), *Sustaining the Global Farm*, selected papers from the 10th International Soil Conservation Organisation Meeting, 24-29 May 1999, Purdue University and USDA-ARS National Soil Erosion Research Laboratory, USA.

The role of ex-situ conservation in restoration practice: lessons from 25 years of plant conservation at the Gurukula Botanical Sanctuary, Wayanad, Kerala

SUPRABHA SESHAN

Gurukula Botanical Sanctuary, Alattil P. O., N. Wayanad, Kerala 670 644 (Tel.: +91 4935 260426; Email: gbsanctuary@vsnl.net)

The Gurukula Botanical Sanctuary (GBS) has been concerned with plant conservation in the Western Ghats since 1981. Our model combats species erosion and habitat degradation through ecosystem gardening and forest-based community education for people from all walks of life. Its effectiveness is evident in the rising regional demand (Kerala, Karnataka and Tamil Nadu) for plant material, habitat restoration methods and education programmes.

GBS's central intention is to restore endangered species and habitats in a highly fragmented landscape, in which only a fraction of original forest remains, and high numbers of species are extracted for human use (up to 50% in areas like Wayanad and Coorg). We estimate that 20% of native species are under threat of extinction within the next 20 years.

Whereas the medicinal plant industry has managed to successfully cultivate less than 100 species in total between all the big nurseries (Dabur, Kottakal, Himalaya etc), GBS has built up extensive populations for 30% of the region's flora (2000 indigenous species across 100 families), through a strategy that involves: high intervention and, a high degree of protection or "leaving alone". Many of the species found in GBS lands are rare and endangered and for some the Sanctuary may be their last refuge. Forty percent of our gene pool is endemic, including orchids, impatiens, peppers, grasses, aroids, acanths, gingers, mosses and ferns. GBS's location (at the edge of a reserve forest), elevation (at 750 metres), and climate (8 months of rain/year) allow us to grow rich and complex semi-natural plant communities representing a wide range of habitats/conditions across the Ghats.

Many botanical gardens are able to grow species under highly controlled situations and most tend to have a higher proportion of exotic flora than native species. These exotics tend to be sturdy representatives from their own regions and moreover, are easy to grow as they have undergone decades of cultivation. However, the collection at GBS is unusual, in terms of both the diversity of native species and the numbers of each species propagated. Wild species are notoriously difficult to propagate in large numbers, yet that is precisely what is needed for ensuring their survival.

Success through ex-situ means requires an understanding of the complexity of the problem and of the diversity of techniques required, including detailed long-term observation, scientific knowledge, sound horticultural practice, rigorous experimentation. Our team has developed a broad knowledge base of 100 plant families covering ecology, biogeography, taxonomy, plant pathology and horticulture. Primary to the whole process is the understanding that ex-situ cannot be divorced from habitat protection. The principle is actually very simple: plants require the forests, and forests require the plants. Where habitat protection has failed then the rescue and conservation of plants attains paramount urgency. Furthermore ex-situ conservation can only work when rigorous standards of plant care and propagation and re-introduction are maintained. Data has to be maintained over a long period of time to observe how accessions, ecotypes and species behave in the wild, semi-wild or cultivated situations.

At GBS we propagate horticulturally challenging (largely herbaceous) plants that occupy highly specialized niches in the wild. These species are not just confined to nursery areas, but occur in regenerating populations (sometimes of several thousand individuals) in recreated habitats along with hundreds of other species that grow without assistance. This is the largest representation of native species in the region and includes both flowering and non-flowering taxa. The plant database, maintained since 1981, has taxonomic, biogeographic, ecological and horticultural data for every species, accession and ecotype. It is an up-to-date groundtruthed statement on the status and distribution of 2000 plant species through the Western Ghats.

Ecosystem gardening involves nudging natural succession processes as well as removing invasive exotics, tending, reseeding and reconstructing habitat structure in a variety of native ecosystems. Re-introduction of species to degraded places where once they were found meets the twin targets of habitat restoration and species conservation and is particularly effective when habitat fragments are grossly reduced and disjunct.

Enriching spaces to fill 'all niches' in complex and relatively mysterious ecosystems like the rainforest, requires strong observational skills and sound theoretical basis. We consider a habitat to be on the way to successful reconstruction when the processes of self-regulation become evident for any population or assemblage of species. The closer we can mimic specific settings in the wild the more likely it is that independent communities will establish themselves.

At GBS it is possible to see two ecosystem mimics: medium elevation wet evergreen rainforest: and montane grassland. In both areas species representation is high. Moreover ecosystem structure and diversity is clearly evident. If at 750 metres we are able to demonstrate an ecosystem mimic from higher elevation, then surely it will be far easier, for example, to restore grassland in the degraded edges of Mukurthi National Park.

At GBS, we also adopt degraded areas and protect them while monitoring the species recovery process over several decades. Over the years we have acquired small parcels of degraded land and restored them piece-by-piece to

native forest. Within 55 acres of land, some 35 are left largely alone. In a few, we have removed exotic plantations to allow native species quick access, and have seen species diversity and forest structure return in areas that have been completely devastated. In 5 acres we intervene in great detail; every plant is known and carefully tended as part of our experiments in habitat reconstruction. A final 5 acres, distributed amongst the rest, provide us with over 50 crop plants including wild edible species, grown in the traditional style of forest farming. This multi-tiered approach maintains the structural and functional elements of the natural forest, with the distinction between healing areas, natural forest, and farm diminishing over time. This is a working model to demonstrate integrated land use to small landholders at a time when cash crop economies are brutally affected by world prices.

It must be remembered that ex-situ conservation for animals poses very different issues and challenges than ex-situ conservation of plants. For example, plants naturally form hybrids. The *Impatiens* genus and most of the Pteridophytes are prone to hybridization in the wild. Secondly, the vast majority of the planet's land area and therefore its vegetation structure has been massively altered through 10,000 years of agriculture and human intervention. We now have to search for pristine wilderness, if indeed it exists anymore. Humanity (and the rest of life) inhabits a landscape of its own making, where natural areas have already been invaded by alien species.

Restoration ecology (including ex-situ conservation) presents alternatives in this context, that we must now deliberate over and consciously implement. This depends on what we value and what we wish our landscapes to be. Do we choose wattle over grassland? Coffee over forest? When 90% of the Western Ghats is under exotic industrial plantation, what will areas recover to when left alone? What is the standard that we can work towards? As an integral part of this comprehensive strategy, sound ex-situ conservation gives us the possibility to broaden our scope.

Suprabha Seshan has lived and worked at the Gurukula Botanical Sanctuary, Wayanad, Kerala, since 1993, prior to which she studied Agro-ecosystem ecology in USA and Earth sciences in the UK. She is the founder of GBS's School in the Forest, a broad collaborative initiative with educators across the region that runs day-programmes on biodiversity (for 40 private or government schools and 30 colleges mostly from North Kerala) and residential programmes (for 15 rural and urban schools from Karnataka, Tamil Nadu and beyond). She has designed and directed several research and restoration projects both at GBS and elsewhere such as Mukurthi National Park and Talacavery Temple Sanctuary. She is an affiliate with Ashoka Innovators for Social Change. In May 2006, on behalf of the team at the Gurukula Botanical Sanctuary, Suprabha received the 2006 Whitley Award for Nature sponsored by WWF-UK , in London.

Suggested reading

GBS 2005. *Notes from the edge: a study of the grasslands of Mukurthi National Park.* Gurukula Botanical Sanctuary & Foundation for Ecological Security.

Contents of CD-ROM

(workshop abstracts and readings)

I. **Workshop Programme & Abstracts**

II. **Society for Ecological Restoration (SER) Primer and Guidelines**

III. **Abstracts of Suggested Reading**

[01 Exotics in restoration.pdf]

D'Antonio, C. & Meyerson, L. A. 2002. Exotic plant species as problems and solutions in ecological restoration: a synthesis. *Restoration Ecology* 10: 703-713.

Exotic species have become increasingly significant management problems in parks and reserves and frequently complicate restoration projects. At the same time there may be circumstances in which their removal may have unforeseen negative consequences or their use in restoration is desirable. We review the types of effects exotic species may have that are important during restoration and suggest research that could increase our ability to set realistic management goals. Their control and use may be controversial; therefore we advocate consideration of exotic species in the greater context of community structure and succession and emphasize areas where ecological research could bring insight to management dilemmas surrounding exotic species and restoration. For example, an understanding of the potential transience of exotics in a site and the role particular exotics might play in changing processes that influence the course of succession is essential to setting removal priorities and realistic management goals. Likewise, a greater understanding of the ecological role of introduced species might help to reduce controversy surrounding their purposeful use in restoration. Here we link generalizations emerging from the invasion ecology literature with practical restoration concerns, including circumstances when it is practical to use exotic species in restoration.

[02 Landscape restoration.pdf]

Holl, K. D., Crone, E. E., Schultz, C. B. 2003. Landscape restoration: moving from generalities to methodologies. *BioScience* 53: 491-502.

Large-scale, landscape-level restoration actions are widely implemented but receive little attention from academic ecologists. We review the methods used to assess the role of these processes in past studies, and suggest ways to use past and ongoing restoration activities to increase our understanding of large-scale processes and improve restoration

projects. To make better use of past restoration, we recommend the use of a number of alternative analytical approaches that have become widely applied in conservation biology and wildlife management but have yet to be adopted in restoration ecology.

[03 Forest landscape restoration manual.pdf]

ITTO & IUCN. 2005. *Restoring forest landscapes: an introduction to the art and science of forest landscape restoration.* ITTO Technical Series 23, International Tropical Timber Organization & IUCN, The World Conservation Union.

This publication presents the latest thinking on the emerging concept of forest landscape restoration (FLR). A joint production of ITTO and IUCN, it is the result of close collaboration between a number of institutions, including ITTO, IUCN, FAO, the Forestry Commission of Great Britain, WWF International, Intercooperation, CIFOR, the Japan Center for Area Studies and the University of Queensland, under the auspices of the Global Partnership on Forest Landscape Restoration (GPFLR). It has also drawn on the ideas and needs of tropical forest restoration practitioners. It builds on the ITTO Guidelines for the Restoration, Management and Rehabilitation of Degraded and Secondary Tropical Forests, which were published by ITTO in collaboration with FAO, Intercooperation, IUCN and WWF International in 2002.

[04 How local is local – genetics in restoration.pdf]

McKay, J. K., Christian, C. E., Harrison, S., Rice, K. J. 2005. "How local is local?"—a review of practical and conceptual issues in the genetics of restoration. *Restoration Ecology* 13: 432-440.

In plant conservation, restoration (the augmentation or reestablishment of an extinct population or community) is a valuable tool to mitigate the loss of habitat. However, restoration efforts can result in the introduction of novel genes and genotypes into populations when plant materials used are not of local origin. This movement is potentially important because many plant species are subdivided into populations that are adapted to local environmental conditions. Here we focus on genetic concerns arising from ongoing restoration efforts, where often little is known about "How local is local?" (i.e., the geographic or environmental scale over which plant species are adapted). We review the major issues regarding gene flow and local adaptation in the restoration of natural plant populations. Finally, we offer some practical, commonsense guidelines for the consideration of genetic structure when restoring natural plant populations.

[05 Restoration of tropical forest in bauxite mined lands.pdf]

Parrotta, J. A., and Knowles, O. H. 1999. Restoration of tropical moist forests on bauxite mined lands in the Brazilian Amazon. *Restoration Ecology* 7: 103-116.

We evaluated forest structure and composition in 9- to 13-year-old stands established on a bauxite-mined site at Trombetas (Pará), Brazil, using four different reforestation techniques following initial site preparation and top soil replacement. These techniques included reliance on natural forest regeneration, mixed commercial species plantings of mostly exotic timber trees, direct seeding with mostly native early succesional tree species, and mixed native species plantings of more than 70 tree species (the current operational restoration treatment at this site). Replicated fixed-radius plots in each treatment and in undisturbed primary forest were used to quantify the canopy and understory structure and the abundance and diversity of all vascular plant species. Treatment comparisons considered regeneration density, species richness and diversity of all floristic categories, and, for trees and shrubs, the relative contribution of initial planting and subsequent regeneration from soil seed banks and seed inputs from nearby primary forests. With the possible exception of the stands of mixed commercial species, which were superior to all others in terms of tree basal-area development but relatively poor in species richness, all treatments were structurally and floristically diverse, with a high probability of long-term restoration success. Of these, the mixed native species plantings appear to be at least risk of arrested succession due to the dominance of a broader range of tree species of different successional stages or expected life spans. In all treatments, several locally important families of primary forest trees (Annonaceae, Chrysobalanaceae, Lauraceae, Palmae and Sapotaceae) were markedly underrepresented due to a combination of poor survival of initial plantings and limitations on seed dispersal from surrounding primary forest.

[SER Primer.pdf in SER primer and guidelines folder**]**

SER 2004. *The SER Primer on Ecological Restoration.* Society for Ecological Restoration International Science and Policy Working Group. 8 pp. http://www.ser.org/content/ecological_restoration_primer.asp

[06 Benefits and impacts of road removal.pdf]

Switalski, T. A., Bissonette, J. A., DeLuca, T. H., Luce, C. H. & Madej, M. A. 2004. Benefits and impacts of road removal. *Frontiers in Ecology and Environment* 2: 21-28.

Road removal is being used to mitigate the physical and ecological impacts of roads and to restore both public and private lands. Although many federal and state agencies and private landowners have created

protocols for road removal and priorities for restoration, research has not kept pace with the rate of removal. Some research has been conducted on hydrologic and geomorphic restoration following road removal, but no studies have directly addressed restoring wildlife habitat. Road removal creates a short-term disturbance which may temporarily increase sediment loss. However, long-term monitoring and initial research have shown that road removal reduces chronic erosion and the risk of landslides. We review the hydrologic, geomorphic, and ecological benefits and impacts of three methods of road removal, identify knowledge gaps, and propose questions for future research, which is urgently needed to quantify how effectively road removal restores terrestrial, riparian, and aquatic habitat and other ecosystem processes.

[07 Organic farming and indigenous seed conservation.pdf]

CIKS 2004. Organic farming and indigenous seed conservation: experiences from Tamilnadu, India. Pages 15-31 in K. Vijayalakshmi & A. V. Balasubramanian (editors) *Seeds of Plenty, Seeds of Hope: On farm conservation of indigenous genetic resources, the Asian Experience*. Centre for Indian Knowledge Systems and COMPAS, Chennai (Bibliography, CD on biodiversity and websites, pages 129-135).

Starting from a handful of five indigenous rice varieties CIKS biodiverse organic farming programme has enlarged into a major effort. Currently, the Centre has more than 130 rice varieties being conserved organically and more than 50 varieties of vegetables providing nutritional security to households. It hopes to expand this effort to the entire state and probably to the entire country.

[08 Conservation of local animal breeds.pdf]

Vivekanandan, P. 2006. Towards a pastoral policy for protection of pastoralists' rights and for conservation of local animal breeds. Pages 119-124 in A. V. Balasubramanian and T. D. Nirmala Devi (editors) *Traditional Knowledge Systems of India and Sri Lanka*. COMPAS series on worldviews and sciences 5, Centre for Indian Knowledge Systems, Chennai.

For the last eight years, SEVA has been involved in the conservation of indigenous animal breeds in Tamil Nadu and promoted herders groups/associations in the following breeding tracts:

i. Umbalacherry cattle breed in Nagapattinam district
ii. Malaimadu cattle breed in Virudhunagar district
iii. Katchakatti Karuppu black sheep breed in Madurai district
iv. Toda buffalo breed in Nilgiris
v. Vembur sheep breed in Thoothukudi District

vi. Pulikulam cattle breed in Madurai and Sivagangai Districts

SEVA has initiated development works such as calf rearing programmes, community bull programmes, shed construction for animals, desilting of ponds to provide drinking water facilities for animals, periodical health check up camps for animals, training programmes for livestock keepers to revitalise indigenous knowledge based health systems for animals (preparation of herbal medicines for animals) and address grazing problems.

SEVA is also one of the founder members of the Indian Pastoralists Network and prepared a Policy Note to protect pastoralists' rights, to provide livelihood support for pastoral communities and in situ conservation of local animal breeds. SEVA has been invited by bodies of the United Nations such as FAO, Rome, and the Convention on Biological Diversity to participate in the workshops on animal genetic resources held in Rome, South Africa, Spain and Brazil over the last five years.

[09 Threats to conservation of Gulf of Mannar.pdf]

Melkani, V. K. Threats to conservation of biodiversity in Gulf of Mannar and proposed remedial actions under GEF-UNDP initiative. (Refer UNDP Project Document 2002).

The primary threats to the globally significant biodiversity of the Reserve are, in order of importance: Habitat destruction; Over-harvesting of marine resources; and Potential, localized land-based marine pollution from a low number of civic point-sources. Habitat destruction (coral reefs, sea grass beds, mangroves) is the most serious threat to the long-term viability of the Park's globally significant resources. Coral mining, though it is illegal, has stripped most of one islands coral and threatens to do the same in other parts of the Park. Sea grass beds are harmed by inappropriate bottom trawling practices. The root causes of habitat destruction are: Lack of integrated management of the reserve (Park and its buffer zone); Insufficient enforcement of protected area laws; Inadequate level of proactive management / Insufficient management information; Lack of clarity in the demarcation of protected area boundaries; Lack of alternative livelihood options. The waters in the buffer zone around the Park currently suffer from the growing cumulative impacts of over-harvesting of marine resources and localized pollution.

[10 Coastal protection and conservation.pdf]

Sreedharan, C. K. & Melkani, V. K. 2006. Enhanced and effective protection and conservation of coastal ecology, biodiversity and communities through active and meaningful support of multi-sectoral stakeholders—a current initiative in the Gulf of Mannar. In National

Workshop on *Coastal Communities and Conservation*, GEER Foundation, Gujarat.

The greatest levels of marine biodiversity are found in tropical developing countries. Livelihood dependence, poverty related issues and developmental priorities provide lesser concern and resources for marine biodiversity conservation. There is need to explore economic and other practical benefits of conservation of marine biodiversity which will sensitize and shape the planning and policy decisions for future focus. Integrated coastal management where all stake holders specially the users of the habitat, managers, planners, economists, natural scientists and policy makers are involved actively in the assessments and the decision making processes that shall follow leading to a close knit strategy for protection of coastal biodiversity and ensuring justified and sustainable use of coastal habitat resources which includes biodiversity. This belief has prompted the Government of Tamil Nadu to establish a statuary Trust to follow-up the integration and coordination of issues and ongoing efforts and future interventions for conservation and sustainable use of biodiversity in GOM region. This is a new and unique initiative which shall surely ensure the better today and tomorrow of coastal bio-diversity and coastal communities.

[11 South Poiganallur.pdf]

***Village Level People's Plans—realities, aspirations, challenges—South Poigainallur, Tamil Nadu*. Praxis—Institute for Participatory Practices.**

The report provide details on the communities of South Poigainallur and includes a description of their traditional use and management of sand dunes. (www.praxisindia.org/reports/SouthPoigainallur.pdf).

[12 Sea turtle manual.pdf]

Choudhury, B.C., Pandav, B., Tripathy, B. & Andrews, H. A. 2003. *Sea turtle conservation: Eco (turtle) friendly coastal development*. A GOI UNDP Project Manual. Centre for Herpetology/Madras Crocodile Bank Trust, Tamil Nadu, India.

Coastal offshore and onshore habitats have great significance for the survival of marine and coastal flora and fauna. As an ecotone between the two habitats, beaches are dynamic and subject to a variety of changes. While the biota of this region have adapted themselves to diurnal, tidal, lunar, seasonal and stochastic events in this zone and any acute or chronic changes in this habitat due to anthropogenic actions can have irreversible negative consequences. In this context, it is important to understand the impact of anthropogenic activities in the coastal zone and how they can be prevented or mitigated. Marine turtles, whose lifecycles are intricately linked to both onshore and offshore coastal habitats, can be important indicators of impacts, since their survival is

dependent on the well being of these habitats . The purpose of this manual is to provide wildlife management authorities, coastal community groups, environmental organizations and other agencies with basic information on sea turtle biology and related coastal issues. We hope to provide some pointers on how to conduct developmental activities in a manner that is ecofriendly in general and sea turtle friendly in particular.

[13 Impacts on sand dunes.pdf]

Mascarenhas, A., Sawkar, K., Untawale, A. G., & Sathe, P. V. 1998. *The distribution of and impacts on sand dune systems of Rajebhag (Nagorcem), Canacona, Goa*. National Institute of Oœanography, Goa.

The report provides an overview of impacts on sand dunes along the Goa coast with implications for management and conservation.

[14 Sand dunes an introduction.pdf]

Mascarenhas, A. 2002. Sand dunes: an introduction. Pages 142-146 in *Fish curry and rice: A source book on Goa, its ecology and life-style*. The Goa Foundation, Mapusa, Goa, India.

Provides a highly readable account of sand dunes and their formation and threats to their conservation in Goa.

[15 Restoration of sand dunes.pdf]

Mascarenhas, A. 2002. Restoration of sand dunes along human-altered coasts: a scheme for Miramar Beach, Goa. Pages 27-31 in *Proceedings of the International Conference on EcoBalance and Life Cycle Assessment in India, February 13-15, 2002*. Indira-Gandhi Institute of Development Research. Mumbai, India.

Provides an account of sand dunes along Miramar and discusses procedures for their restoration such as artificial nourishment, fencing, and planting of appropriate dune plant species.

[16 Mangrove restoration.pdf]

Ellison, A. M. 2000. Mangrove restoration: do we know enough? *Restoration Ecology* 3: 219-229.

Mangrove restoration projects have been attempted, with mixed results, throughout the world. In this paper, I first examine goals of existing mangrove restoration projects and determine whether these goals are clear and adequate, and whether or not they account for the full range of biological diversity and ecological processes of mangrove ecosystems. Many restored mangrove forests resemble forest plantations rather than truly integrated ecosystems, but mangrove plantations can be a first step toward mangrove rehabilitation. Mangrove restoration projects that involve associated aquaculture or mariculture operations tend to be

more likely to approximate the biological diversity and ecological processes of undisturbed mangrove ecosystems than are projects that focus only on the trees. These integrated restoration projects also provide a higher economic return than do silvicultural projects alone. Second, I briefly assess whether existing ecological data are sufficient to undergird successful restoration of mangal and define criteria for determining whether or not a mangrove ecosystem has been restored successfully. These criteria include characteristics of vegetation (forest) structure, levels of primary production, composition of associated animal communities, and hydrology. Finally, I suggest ways to improve mangrove restoration projects and identify key research needs required to support these efforts. Ecological theories derived from other wetland and upland systems rarely have been applied to either "basic" or "applied" mangrove forest studies, to the detriment of restoration projects, whereas lessons from restoration of the relatively species-poor mangrove ecosystems could be beneficially applied to restoration projects in other contexts. An international database of mangrove restoration projects would reduce the likelihood that unsuccessful restoration projects would be repeated elsewhere. Clear criteria for evaluating success, greater accessibility of information by managers in the developing world, intensified international cooperation, and application of relevant ecological theories will improve the success rate of mangrove restoration projects.

[17 Mangrove rehabilitation.pdf]

Field, C. D. 1998. Rehabilitation of mangrove ecosystems: an overview. *Marine Pollution Bulletin* 37: 383-392.

The concept and goals of mangrove ecosystem rehabilitation are considered and contrasted with ideas of eco- system restoration. Three reasons for mangrove rehabilitation: conservation and landscaping; multiple use systems for high sustainable yield and protection of coastal areas, are then examined in detail. In each case, the underlying philosophy and limitations are presented. The practical problems of site selection for mangrove planting and techniques for regenerating mangroves are then considered. Some comments and data are then offered on mangrove ecosystem rehabilitation that is being carried out world-wide. Comment is made on the paucity of information. The practice and importance of monitoring and maintaining rehabilitated mangrove ecosystems is then presented. Finally, there is a discussion on the future management and research needs of mangrove ecosystem rehabilitation.

[18 Status and management of coral reefs.pdf]

Wilhelmsson, D., Edward, J. K. P., Rajasuriya, A., Tamelander, J. & Perera, N. 2000. Assessing the status and improving management of coral reef resources: experiences and achievements in South Asia. Pages 39-55 in Cesar, H. (editor), *Collected Essays on the Economics of Coral Reefs*. CORDIO, Kalmar University, Sweden.

Abstract not available.

[19 Coral transplantation.pdf]

Edwards, A. J. & Clark, S. 1998. Coral transplantation: a useful management tool or misguided meddling? *Marine Pollution Bulletin* 37: 474-487.

The primary objectives of coral transplantation are to improve reef `quality' in terms of live coral cover, biodiversity and topographic complexity. Stated reasons for transplanting corals have been to: (1) accelerate reef recovery after ship groundings, (2) replace corals killed by sewage, thermal effluents or other pollutants, (3) save coral communities or locally rare species threatened by pollution, land reclamation or pier construction, (4) accelerate recovery of reefs after damage by Crown-of-thorns starfish or red tides, (5) aid recovery of reefs following dynamite fishing or coral quarrying, (6) mitigate damage caused by tourists engaged in water-based recreational activities, and (7) enhance the attractiveness of underwater habitat in tourism areas. Whether coral transplantation is likely to be effective from a biological standpoint depends on, among other factors, the water quality, exposure, and degree of substrate consolidation of the receiving area. Whether it is necessary (apart from cases related to reason 3 above), depends primarily on whether the receiving area is failing to recruit naturally. The potential benefits and dis-benefits of coral transplantation are examined in the light of the results of research on both coral transplantation and recruitment with particular reference to a 4.5 year study in the Maldives. We suggest that in general, unless receiving areas are failing to recruit juvenile corals, natural recovery processes are likely to be sufficient in the medium to long term and that transplantation should be viewed as a tool of last resort. We argue that there has been too much focus on transplanting fast-growing branching corals, which in general naturally recruit well but tend to survive transplantation and re-location relatively poorly, to create short-term increases in live coral cover, at the expense of slow-growing massive corals, which generally survive transplantation well but often recruit slowly. In those cases where transplantation is justified, we advocate that a reversed stance, which focuses on early addition of slowly recruiting massive species to the recovering community, rather than a short-term and sometimes short-lived increase in coral cover, may be more appropriate in many cases.

[20 Economics of coral reef restoration.pdf]

Spurgeon, J. P. G. & Lindahl, U. 2000. Economics of coral reef restoration. Pages 125-136 in Cesar, H. (editor), *Collected Essays on the Economics of Coral Reefs*. CORDIO, Kalmar University, Sweden.

This chapter provides an introduction to the economics of coral reef restoration. A comparison of coral restoration schemes from four countries indicates that costs can vary from some US$ 13,000 per ha to over a hundred million US$ per ha. However, it also reveals that cost estimates in the literature are not readily comparable, and that many cost components of restoration are ignored. Little work has been conducted into the potential benefits of coral restoration. This issue is briefly considered with reference to the case studies. The chapter suggests that a benefit–cost analysis approach should be used more often to help assess the justification for coral reef restoration and to improve the efficiency of any such expenditure. It is clear that a greater understanding of the economics and biology of coral reef restoration is required, as well as consideration of alternative management options, before being able to determine with confidence whether coral reef restoration really is an effective use of available funds.

[21 Reintroduction of eelgrass.pdf]

van Katwijk, M. M. 2003. Reintroduction of eelgrass (*Zostera marina* L.) in the Dutch Wadden Sea: a research overview and management vision. Pages 173-197 in W. J. Wolff, K. Essink, A. Kellermann & M. A. van Leeuwe (editors), *Challenges to the Wadden Sea*. Proceedings of the 10th International Scientific Wadden Sea Symposium, Groningen, 2000. Ministry of Agriculture, Nature Management and Fisheries / University of Groningen, Department of Marine Biology, 2003.

A research overview and management vision are presented, resulting from 13 years of research into the possibilities of reintroduction of the seagrass *Zostera marina* in the Dutch Wadden Sea. It is concluded that presently (1) suitable donor populations are available, (2) light is not limiting to *Z. marina* to at least 0.80 m below mean sea level, (3) below -0.20 m mean sea level, water movements (particularly the duration) are too severe, unless shelter is available, (4) high nutrient loads restrict the area of high potential *Z. marina* habitats to areas with freshwater influences, (5) muddy sediments and a permanent layer of water during low tide are favourable, (6) two types of *Z. marina* occurred in the pre-1930s Wadden Sea, each suitable for a different tidal depth. Main recommendations are to (1) restore estuarine gradients, (2) decrease nutrient (particularly nitrogen) loads, (3) restore areas with shelter (for example created by mussel beds, which have largely disappeared but probably can be restored, actively or passively), (4) carefully select

transplantation sites: locally (muddy sediments with a permanent layer of water during low tide) and regionally (freshwater influence and shelter) (5) improve the present GIS map with the *Z. marina* habitat suitability of the Dutch Wadden Sea by including data on salinity and nutrient loads, and (6) prohibit fisheries activities in potential seagrass habitats.

[22 Notes on TDEF.pdf]

Blanchflower, P. 2003. Some notes on the tropical dry evergreen forest of south India. Unpublished report, Auroville, India.

Abstract not available.

[23 Restoration of TDEF.pdf]

Blanchflower, P. 2005. Restoration of tropical dry evergreen forest of Peninsular India. *Biodiversity* 6(3): 17-24.

The Tropical Dry Evergreen Forest (TDEF) of India is only found on the south eastern seaboard of the peninsular. It has a very limited range, and extends only 60 km inland. The TDEF occurs in an area of high population density and consequently it is the rarest type of forest ecosystem found in the subcontinent. The establishment of the Auroville International Township in 1968 initiated a major work of eco-restoration which has turned a highly eroded lateritic plateau into a re-emerging ecosystem of the TDEF. The work now spreads out beyond the boundaries of the international township and involves working with local people, especially women and children. Many lessons have been learnt and the work continues to reintegrate the forest in the social fabric of a rapidly changing rural environment.

[24 Regeneration in dry forests.pdf]

Gerhardt, K. & Hytteborn, H. 1992. Natural dynamics and regeneration methods in tropical dry forests: an introduction. *Journal of Vegetation Science* 3: 361-364.

Most disturbed ecosystems within the tropical dry forest area, i.e. within the above-mentioned rainfall and drought conditions, will naturally regenerate into forest if left alone. However, natural savannas may to some extent develop within these limits as well, i.e. on deviating edaphic properties. Specific restoration methods are now being developed, such as direct sowing, enrichment planting, direct planting, favouring the natural regeneration and resprouting capacity. Most species do not need to be inoculated when planted in dry forest pastures because the vesicular-arbuscular mycorrhizae are usually already present in grass root systems and can therefore be shared by the seedlings. The rate and direction of the natural regeneration in highly disturbed forests depend partly on the distance from the seed sources, the abundance of already

existing shrubs and trees, and the former type and intensity of management, including the introduction of foreign pasture grasses, fire and compaction by cattle and mechanized management. As wind-dispersed seeds enter easily into the natural restoration process, planting could be restricted to animal-dispersed trees.

[25 Seeds and seedlings dry forests.pdf]

Khurana, E. & Singh, J. S. 2001. Ecology of seed and seedling growth for conservation and restoration of tropical dry forest: a review. *Environmental Conservation* 28:39–52.

Dry forests are among the most threatened ecosystems and have been extensively converted into grasslands, secondary forest, savanna or agricultural land. Knowledge of seed germination and seedling establishment is required for the success of efforts on restoration of these forests. This review focuses on the ecological requirements at seed and seedling stages, and collates the current knowledge of seed viability, dormancy, germination pattern and seedling behaviour of dry tropical tree species. The spatio-temporal variations within the tropical dry forest biome in soil moisture, light, temperature, nutrients and intensity of predation, significantly affect the seed and seedling traits of component species. The majority of dry tropical species possess orthodox seeds which are characterized by dormancy, while a few have recalcitrant seeds which possess little or no dormancy. Seed coat dormancy, which can be overcome by mechanical or acid scarification or sometimes by transit through animal guts, is most prevalent in the dry tropical forest species. Persistent species dominating the undisturbed portions of the forest have bigger seeds compared to those that mostly occur in disturbed regions and require shade for the survival of their seedlings. Shade demand is associated with drought endurance, and may be absolute in species such as *Guettarda parviflora* and *Coccoloba microstachya*, or facultative as in *Plumeria alba* and *Bursera simaruba*. The fluctuation in temperature significantly affects seed germination in several species of dry Afromontane forest trees of Ethiopia. Seedling mortality is primarily a function of moisture stress during the dry period. Adaptive responses of seedlings to drought stress include increased chlorophyll content, for example in Acacia catechu, and root biomass, as in several dry forest species (for example *Drypetes parvifolia, Teclia verdoornia*) of Ghana. Mulching, application of fertilizers, interplanting of leguminous species and mycorrhizal inoculation are useful tools for promoting seedling establishment in nutrient-poor dry tropical soils. Periodic forest fires, and predation affect recruitment and seedling development according to their intensity. Many species experiencing frequent fires have evolved thick seed coats, produce fire-hardy seedlings, or escape the effect by temporal separation of seed dispersal

and fire events. Predation may result in abortion of fruits or may enhance germination and recruitment by scarification and dispersal, as in most species of the Guanacaste dry forest. Exposure to elevated CO_2 has increased relative growth rate, total leaf area and water use efficiency in most of the dry tropical seedlings tested, but the magnitude of the effect has varied markedly among species. Due to the availability of a large source of energy, large seeds show higher germination percentage, greater seedling survival and increased growth. Seeds originating from different provenances exhibit differences in germination and seedling growth (for example *Prosopis cineraria, Albizia lebbeck, Eucalyptus camaldulensis* and *Acacia mangium*), efficiency of nodulation (for example *Acacia nilotica, A. auriculiformis*), and stress resistance (for example *Populus deltoides*, *Dalbergia sissoo*). The review points out the need for coordinated, long-term, field-based studies for identification of multiple cues and niches for germination, on seed and seedling dynamics in response to fire, and on within-species genetic variability for selection of suitable provenances. Field-based studies at species and community levels are also needed to permit manipulations of biotic components to augment the recruitment of desired species and to suppress that of undesirable species.

[26 Ecology of tropical dry forest.pdf]

Murphy, P. G. & Lugo, A. E. 1986. Ecology of tropical dry forest. *Annual Review of Ecology and Systematics* 17: 67-88.

Comprehensive review of characteristics of tropical dry forest structure and dynamics.

[27 Seed banks in dry forest.pdf]

Skoglund, J. 1992. Role of seed banks in vegetation dynamics and restoration of dry tropical ecosystems. *Journal of Vegetation Science* 3: 357-360.

This paper reviews studies on seed banks in tropical dry vegetation and, for comparison, some wet tropical and dry subtropical vegetation. The first general conclusion is that tropical seed banks are smaller than those in temperate ecosystems. Many studies are devoted to only one species, among which are several *Acacia* species, both tropical and subtropical, some of which reach densities in the seed bank of up to 10,000 seeds/m^2. The lesser importance of the seed bank strategy in tropical species may be related to higher risks of seed loss through higher mortality (fire, predation, pathogens, etc.), or to intermittent germination occasions in relation to ephemeral favourable conditions (e. g. rains during the dry season). Regarding vegetation dynamics, the importance of seed banks and regeneration from seeds is most pronounced in larger forest gaps. Examples are discussed of rapid

success to forest of savannas after protection from fire, which is partly due to regeneration from the seed bank. The significance of seed banks in vegetation restoration projects is outlined and the need for additional sowing of seeds of important species underlined.

[28 Restoration of dry forests.pdf]

Vieira, D. L. M. & Scariot, A. 2006. Principles of natural regeneration of tropical dry forests for restoration. *Restoration Ecology* 14: 11-20.

Tropical dry forests are the most threatened tropical terrestrial ecosystem. However, few studies have been conducted on the natural regeneration necessary to restore these forests. We reviewed the ecology of regeneration of tropical dry forests as a tool to restore disturbed lands. Dry forests are characterized by a relatively high number of tree species with small, dry, wind-dispersed seeds. Over small scales, wind-dispersed seeds are better able to colonize degraded areas than vertebrate-dispersed plants. Small seeds and those with low water content are less susceptible to desiccation, which is a major barrier for establishment in open areas. Seeds are available in the soil in the early rainy season to maximize the time to grow. However, highly variable precipitation and frequent dry spells are important sources of mortality in seeds and seedlings. Collecting seeds at the end of the dry season and planting them when soil has sufficient moisture may increase seedling establishment and reduce the time they are exposed to seed predators. Germination and early establishment in the field are favored in shaded sites, which have milder environment and moister soil than open sites during low rainfall periods. Growth of established seedlings, however, is favored in open areas. Therefore, clipping plants around established seedlings may be a good management option to improve growth and survival. Although dry forests have species either resistant to fire or that benefit from it, frequent fires simplify community species composition. Resprouting ability is a noticeable mechanism of regeneration in dry forests and must be considered for restoration. The approach to dry-forest restoration should be tailored to this ecosystem instead of merely following approaches developed for moister forests.

[29 Faunal underpasses in rainforest roads.pdf]

Goosem, M., Izumi, Y. & Turton, S. 2001. Efforts to restore habitat connectivity for an upland tropical rainforest fauna: a trial of underpasses below roads. *Ecological Management and Restoration* 2: 196-202.

Four large underpasses, specifically designed for movements by fauna, form part of a major road upgrade project on the Atherton Tablelands in northeast Queensland, Australia. We describe the design and rationale of a project to test their effectiveness in restoring habitat continuity for

tropical rainforest fauna. The large blocks of upland rainforest divided by the road are recognized for their high faunal conservation significance, forming habitat for many rare or threatened species. Ecologists, road engineers and the Atherton Tablelands conservation community have united with a common conservation goal: to design the 'furniture' within the underpasses and accomplish rainforest revegetation to provide protective cover and attract fauna to underpass entrances. Prior to construction, small mammals were trapped weekly for several months in habitats close to the road upgrade. The small mammal community comprised grassland species in abandoned pasture and differed significantly from the rainforest specialists found in three closed canopy habitats: rainforest edge, rainforest interior and *Lantana* shrubland. Rainforest restoration works designed to restore connectivity for rainforest fauna across this abandoned pastureland (via the underpasses to major rainforest blocks to the north and south of the road) are currently in progress. Monitoring of the effectiveness of the underpasses in allowing faunal movements will involve the use of infra-red-triggered cameras within the underpasses and near underpass entrances, and a survey of road-killed fauna both prior to and post-construction. Further examination of small mammal community structure and movements, with respect to both the new road and the underpasses, will be undertaken once rainforest plantings have become established. This evaluation should provide insights for further road-associated restoration projects in rainforest regions.

[30 A & B Restoration of tropical forest.pdf]

Lamb, D., Erskine, P. D., & Parrotta, J. A. 2005. Restoration of degraded tropical forest landscapes. *Science* 310: 1628-1632.

Online Material: www.sciencemag.org/cgi/content/full/310/5754/1628/DC1

Authoritative recent review with case studies.

The current scale of deforestation in tropical regions and the large areas of degraded lands now present underscore the urgent need for interventions to restore biodiversity, ecological functioning, and the supply of goods and ecological services previously used by poor rural communities. Traditional timber plantations have supplied some goods but have made only minor contributions to fulfilling most of these other objectives. New approaches to reforestation are now emerging, with potential for both overcoming forest degradation and addressing rural poverty.

[31 Rainforest restoration in Anamalais.pdf]

Mudappa, D. & Raman, T. R. S. *in press.* Rainforest restoration and wildlife conservation on private lands in the Western Ghats. In Shahabuddin, G. & Rangarajan, M. (editors) *Making Conservation Work*. Permanent Black, New Delhi.

A major conservation issue, particularly in the tropics, is habitat loss and fragmentation due to developmental activities and increasing human populations. Ecologists today recognise that much of the once-pristine forests that are now secondary forests, as well as large areas outside existing conservation reserves, harbouring significant levels of biological diversity need to be targeted for long-term conservation. Governmental agencies such as the Forest Department and the conservation community have come to accept that the conventional patrol and protect method has its limitations in addressing the increasing threats to such conservation areas. A complementary strategy is to develop conservation plans for protection and improvement by ecological restoration of forests, particularly isolated fragments and degraded areas on private lands. This requires bridging gaps between private landowners, governmental agencies, and non-governmental conservation organisations and fostering efforts based on mutual cooperation and collaboration as well as developing positive incentives for private landholders involved in conservation of forests and biological diversity. In this paper, we discuss one of the first examples of such an effort of sharing responsibility for long-term conservation in a highly disturbed tropical rainforest region of the Western Ghats.

[32 A & B Rainforest and grassland restoration.pdf]

NCF & VCT. 2006. *Principles for rainforest and grassland restoration in the Anamalai hills*. Nature Conservation Foundation, Mysore, and Vattakanal Conservation Trust, Kodaikanal.

Manual in English and Tamil (A & B) with general guidelines for restoration of mid-elevation tropical rainforest in the Anamalai hills and shola-grassland ecosystems in the Palni and Anamalai hills.

[33 Linkage restoration.pdf]

Tucker, N. I. J. 2000. Linkage restoration: interpreting fragmentation theory for the design of a rainforest linkage in the humid Wet Tropics of north-eastern Queensland. *Ecological Management and Restoration* 1: 35-41.

Studies of forest fragmentation, particularly in the species-rich tropical zone, have contributed significantly to our understanding of its effects and impacts, and allow us to predict a cascade of flow-on effects likely to emerge in the coming decades. Practical management strategies to combat these effects, however, have not been forthcoming, despite

intuitive assumptions and a growing body of scientific evidence that maintaining and restoring habitat connectivity is likely to be critical for the long-term persistence of many life forms in these fragmented landscapes. This paper reviews the potential problems involved with linkages, and examines some of the strategies adopted to overcome these issues in a linkage restoration project on the Atherton Tableland, in the Wet Tropics of north-eastern Australia. The paper concludes with the suggestion that restoration projects, such as the Donaghy's Corridor example, offer opportunities for researchers and practitioners to collaboratively observe and validate these strategies, and develop 'real world' techniques to reverse the ecological, social and economic effects of forest fragmentation.

[34 Restoration and natural capital.pdf]

Aronson, J., Clewell, A. F., Blignaut, J. N., & Miltone, S. J. 2006. Ecological restoration: a new frontier for nature conservation and economics. *Journal for Nature Conservation* 14: 135-139.

Ecological restoration is still perceived by many conservationists, and the majority of economists, as a diversion, a delusion, and – far worse – a waste of money. In this paper we point out that restoration is in fact complementary not only to nature conservation but also to sustainable, equitable socio-economic development, through job creation and livelihood opportunities, with thanks to the augmentation of the natural capital base on which all economies rely. In developing countries, where most biodiversity hotspots occur, both conservation of nature and the restoration of degraded ecosystems will only find local support if they are clearly linked to socio-economic development. Conversely, sound socioeconomic development in the environmentally damaged portions of those countries undoubtedly will require ecological restoration of the natural capital base. Nature conservation, ecological restoration, and sustainable economic development policies should therefore be planned, budgeted and executed conjointly.

[35 Novel ecosystems.pdf]

Hobbs, R. J., Arico, S., Aronson, J. & 15 others. 2006. Novel ecosystems: theoretical and management aspects of the new ecological world order. *Global Ecology and Biogeography* 15: 1-7.

We explore the issues relevant to those types of ecosystems containing new combinations of species that arise through human action, environmental change, and the impacts of the deliberate and inadvertent introduction of species from other regions. Novel ecosystems (also termed 'emerging ecosystems') result when species occur in combinations and relative abundances that have not occurred previously within a given biome. Key characteristics are novelty, in the form of new

species combinations and the potential for changes in ecosystem functioning, and human agency, in that these ecosystems are the result of deliberate or inadvertent human action. As more of the Earth becomes transformed by human actions, novel ecosystems increase in importance, but are relatively little studied. Either the degradation or invasion of native or 'wild' ecosystems or the abandonment of intensively managed systems can result in the formation of these novel systems. Important considerations are whether these new systems are persistent and what values they may have. It is likely that it may be very difficult or costly to return such systems to their previous state, and hence consideration needs to be given to developing appropriate management goals and approaches.

[36 Hydrological effects of bluegum.pdf]

Samra, J. S., Sikka, A. K., & Sharda, V. N. 2001. Hydrological implications of planting bluegum in natural shola and grassland watersheds of Southern India. Pages 338-343 in D. E. Stott, R. H. Mohtar and G. C. Steinhardt (editors), *Sustaining the Global Farm*, selected papers from the 10th International Soil Conservation Organisation Meeting, 24-29 May 1999, Purdue University and USDA-ARS National Soil Erosion Research Laboratory, USA.

The paper presents the results of a long-term (1968-92) experimental watershed study conducted by Central Soil & Water Conservation Research & Training Institute, Research Centre Udhagamandalam at Glenmorgan in Nilgiris on the hydrological implications, tree growth and economics of planting *Eucalyptus globulus* (bluegum) in a natural mixed 'Shola' and grassland forest watershed following the paired watershed technique. Grassland area of 18.7 ha (59%) of a watershed was replaced with bluegum in one of the two comparable watersheds of 32 ha each during 1972, after a calibration period of four years (1968-71). Ten years rotation cycle was followed for harvesting and coppice regeneration. Average annual reduction in water yield of the order of 16% and 25.4% was determined from the bluegum watershed over the natural grassland during the first and second rotation, respectively. Maximum reductions in run-off were observed during July to October and this was attributed to greater availability of rainfall and hence its utilisation during this period. Appreciable reduction in low flow as a result of decline in base flow could be predicted with Low Flow Index (LFI) decreasing by 2.0 and 3.75 times, in the first and second rotation, respectively. This dry period, though small, is very crucial for sustaining water supply to hydroelectric reservoirs. Moderation in peak discharge rates was also observed as a result of bluegum plantation. The biomass and economic returns for the second rotation were also 42% and 40% higher than the first rotation, but at a cost of 60% more reduction in water yield during the second

rotation over the first rotation. The coppiced bluegum depleted soil moisture from deeper soil layer whereas during the first rotation the extraction was mostly confined to the surface layers.

Other Reading:

GBS 2005. *Notes from the edge: a study of the grasslands of Mukurthi National Park.* Gurukula Botanical Sanctuary & Foundation for Ecological Security.

Tamilnadu afforestation project funded by Japan Bank for International Cooperation (JBIC). http://www.tnforests.nic.in/JFM.htm